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ART-MANUFACTURES

IN THE DESERT.) FRONTISPIECE.

THE APPLICATION

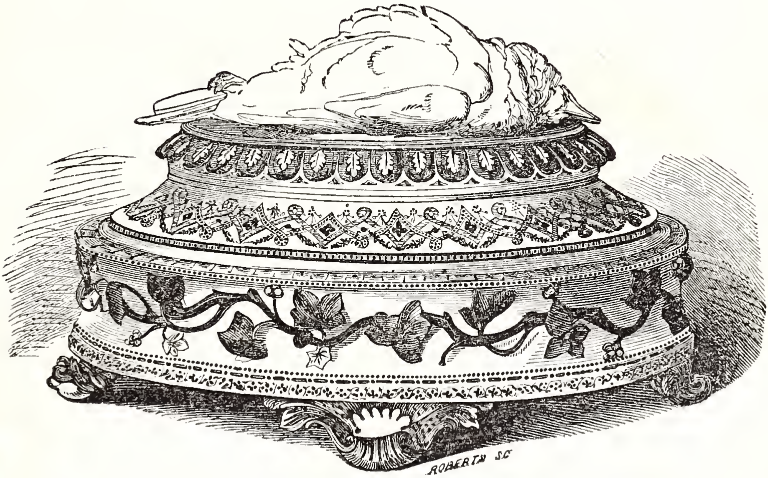
OF

ART TO MANUFACTURES.

With 150 Illustrations.

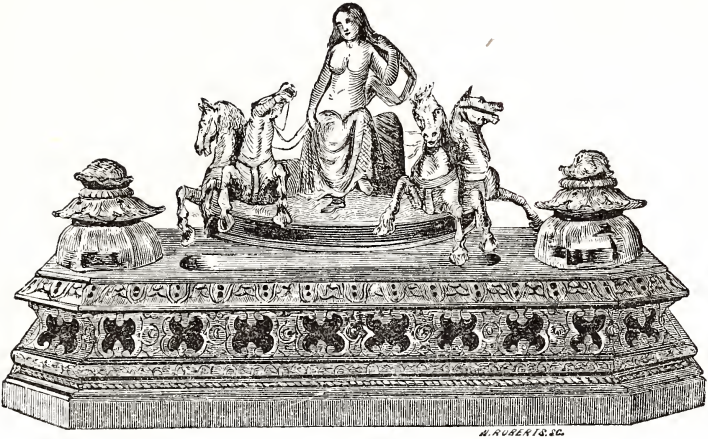
BY

GEORGE C. MASON.



NEW YORK:
G. P. PUTNAM, 321 BROADWAY.
1858.

"We should do our utmost to encourage the beautiful, for the useful encourages itself."



PREFACE.

IN offering this little work to the public, the author wishes to take no credit to himself for originality. Much here presented is known to those who are familiar with such branches of manufactures as most readily admit of an artistic display in their production, and possibly there may be nothing in these pages that has not been said before; but in no one work, treating of Metals or Ceramics, will all the materials here brought together be found. The object has been to collect such facts connected with their history, with some particulars of the various processes of converting the raw material into the finished goods, as are most likely to prove interesting, and to call attention to the importance of a

higher development of art in our manufactures. For this purpose he has freely drawn from Labarte's Arts of the Middle Ages, Phillips' Metallurgy, Holland's Treatise on the Metals, Napier's Electro-Metallurgy, Porter on Porcelain and Glass, Hunt's Merchant's Magazine, Ure on the Arts and Manufactures, The Scientific American, Crystal Palace Record, London Art Journal—which is doing much to improve public taste in this country and in England—and many other works, to which he is indebted in a less degree, and which would be referred to here were it necessary. To information derived from these sources, he has added some knowledge of the practical operations of the workroom and at the forge; and if in this humble way he can call attention to the importance of applying Art more generally to our manufactures, he will not have labored in vain.

The refining influence of Art is much needed; but to its full development we may not look forward so long as its importance is imperfectly understood. At present it suffers from constant abuse on the one hand, and utter neglect on the other—on the right, gaudiness, incongruity, and an entire want of feeling; on the left, an indifference that is equally culpable. To do away with these extremes, the surest way is to place articles of unexceptionable form and finish within the reach of all; so that the eye, daily becoming more and more familiar with that which should be valued as much for its beauty as for its utility, will in time learn not only to appreciate both of these qualities, but will never willingly see them separated, even in the most ordinary articles of daily use.

It is related of Constable, that when West took up a piece of chalk and showed him how he could improve the lights and shades of his picture, he remarked that it was the best lecture, because a practical one, on chiaroscuro he ever heard. The same end was had in view in preparing these pages on the application

of Art to Manufactures, and as all technical terms have been in a great measure avoided, and efforts have been made to clearly present every process, it is to be hoped they will interest and improve the rising generation, for whose especial benefit they have been prepared.

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ART-MANUFACTURES.

CHAPTER I.

METALS.

THE Metals are a class of simple substances, possessed of a peculiar lustre, having the property of conducting heat and electricity with great facility; but both in their chemical and physical properties they differ very much from each other, and are consequently applicable to a great variety of uses.

The ancients were acquainted with seven metals, and these they designated by the names of the planets, and represented by symbols supposed to have some mysterious allusion to those bodies. Gold was called the Sun, silver the Moon, mercury Mercury, copper Venus, iron Mars, tin Jupiter, and lead Saturn. But limited as was their knowledge of the metals, they understood the art of working those with which they were familiar, and carried it to a degree hardly to be surpassed by the most skilful artists of the present day, assisted by the numerous inventions of modern times.

The metals at present known amount to fifty-one in number, and are enumerated in the following table:

Aluminum,*	Glucinum,*	Niobium,	Tantalum,
Antimony,	Gold,	Norium,*	Tellurium,
Arsenic,	Ilmenium,	Osmium,	Terbium,*
Barium,*	Iridium,	Palladium,	Thorium,*
Bismuth,	Iron,	Pelopium,	Tin,
Cadmium,	Lanthanum,*	Platinum,	Titanium,
Calcium,*	Lead,	Potassium,*	Tungsten,
Cerium,*	Lithium,*	Rhodium,	Uranium,
Chromium,	Magnesium,*	Ruthenium,	Vanadium,
Cobalt,	Manganese,	Silicium,*	Yttrium,*
Copper,	Mercury,	Silver,	Zinc,
Didymium,*	Molybdenum,	Sodium,*	Zirconium.*
Erbium,*	Nickel,	Strontium,*	

These are divided into two classes. The first consists of those which have so great an affinity for oxygen that they combine with it at the ordinary temperature of the atmosphere, and become rapidly oxidized, even when protected from the influence of moisture, and are consequently never used in the arts in an uncombined state. They are marked in the table above with an asterisk.

Those of the above metals which have been applied to useful purposes are either employed in combination with other simple substances, or united with acids in the form of salts, and in this state furnish the arts with a most valuable series of compounds. Thus, those in the first part of the series, when associated with oxygen, severally yield potash, soda, baryta, strontia, lime, magnesia, and alumina, which, either in their uncombined state, or united with acids, forming salts, are of hourly application to our wants. The other metals of this class have not hitherto been usefully applied, which arises from the circumstance that some of them do not occur in sufficient abundance to admit of their advantageous treatment, whilst the preparation of others is attended with great expense, and they are therefore replaced by bodies which allow of being manufactured at a cheaper rate.

The second class consists of those metals which have so slight an affinity for oxygen as to be little affected by it at ordinary

temperatures. They comprise all those in the table not marked with an asterisk. They are extremely numerous, but in order to render them extensively applicable in an uncombined state, it is necessary they should fill certain physical conditions, without which they will be of little value.

In the first place they must possess a certain tenacity and malleability, without which it would be impossible to manufacture them into the various forms they are constantly required to assume. It is also important that the ores from which they are obtained should be found in considerable quantities, and that the extraction of the metal should not be attended with any extraordinary difficulty or expense, otherwise they could only be employed for special purposes for which others were unfitted, and could therefore never come into general use.

The more brittle metals are seldom employed alone, but usually in combination with others possessing a higher degree of malleability and ductility, and thus alloys are frequently obtained which exhibit most remarkable and valuable properties, combining, to a certain extent, the characteristics of the several metals of which they are formed.

The metals sufficiently malleable to enable them to be employed in an uncombined state are the following:

Gold,	Iridium,	Iron,	Cadmium,
Silver,	Mercury,	Cobalt,	Copper,
Platinum,	Tin,	Nickel,	Lead.
Palladium,	Manganese,	Zinc,	

Of these, however, many have not been employed in the arts; and this arises either from the scarcity of the ores from which they are obtained, or from their place being advantageously supplied by other metals which can be procured at a cheaper rate.

The metals that possess a great degree of opacity are remarkable for a peculiar lustre, called metallic. All, however, are not equally opaque, as gold, when reduced to extremely thin leaves, transmits rays of green light. Silver leaf of one hundred thousandth of an inch in thickness is perfectly opaque; but very thin leaves of an alloy of silver and gold appear of a blue color, when viewed by transmitted light. The lustre of metals is a con-

sequence of their opacity, and depends on their power of reflecting light. When reduced to the state of powder their peculiar metallic appearance disappears; but it is immediately reproduced by rubbing with a burnisher, or any other hard and smooth substance.

Most of the metals, when in a finely divided state, are of a gray color; but when consolidated and polished, approach more nearly to white. The colors of some of them are, however, very decided. Thus copper and tellurium are red; gold is yellow, and lead is blue. The alloys usually possess, to a certain extent, the colors of the metals of which they are composed. Those resulting from the combination of two or more gray or white metals will themselves be gray or white; but if a colored metal enter into the combination, the alloy will assume its color in a marked degree, although if the proportion of the colored metal be small compared with the amount of that which is not colored, this is not always very apparent.

The metals differ from each other in no respect more than with regard to hardness. Those which are pure are usually less hard than their alloys, and many of them are so soft as to admit of being easily scratched with the nail, or even moulded between the fingers. Titanium and manganese are harder than steel; platinum, palladium, copper, gold, silver, tellurium, bismuth, cadmium, and tin are scratched by calc spar; chromium and rhodium scratch glass; nickel, cobalt, iron, antimony and zinc are scratched by glass; lead is scratched by the nail; potassium and sodium are as soft as wax at 60° Fah., and mercury is liquid at ordinary temperature.

All the metals are capable of assuming, under favorable circumstances, the crystalline form. Many of them, particularly gold, silver, copper, and bismuth, occur crystallized in nature, and are found in either cubes or octahedrons, or in some of the derivative forms. Antimony is, however, an exception to the rule, and affords rhomboidal crystals. In order to crystallize a metal artificially, it is sometimes sufficient to melt a few ounces in a crucible, and having permitted it to cool on the surface, to pierce the crust formed, and allow the interior to flow out. By this

means very beautiful crystals of bismuth may be obtained; but in the case of some of the less fusible metals, larger masses and slower cooling are necessary to produce this effect.

It also frequently happens that one metal may be precipitated in a crystalline form by placing a strip of another metal in the solution of its salts. In this way silver is deposited by mercury, and a piece of zinc placed in a solution of acetate of lead, precipitates the latter in feathery crystals. Gold is occasionally deposited in this form from its ethereal solutions, and a stick of phosphorus produces the same effect. Nearly all the metals yield crystals when deposited from their solutions by electric currents of feeble intensity.

When a piece of metal is struck by a hammer, it either flattens under the blow or splits with more or less facility into fragments; to the former quality the name of malleability is applied, whilst metals possessing the latter peculiarity are called brittle. The malleable metals may be reduced into thin leaves either by the hammer or by the flatting mill, an operation performed by passing the metal between heavy rollers, which reduces it to the required thickness. During this artificial compression of the metals their molecular structure rapidly undergoes a change, and those which at first were soft, and passed readily through the mill soon become brittle and difficult to work. It is then said to be "rash" and requires to be softened by being heated to redness, and afterwards allowed to cool down very gradually to the temperature at which it is worked. This process is called annealing.

Gold is the most malleable of the metals, and is frequently made into leaves of only one two-hundred-thousandth of an inch in thickness, each grain of which is found to cover a surface of fifty-four square inches. The metals are arranged in the following list according to their malleability:

1 Gold,	4 Tin,	7 Lead,	10 Nickel,
2 Silver,	5 Cadmium,	8 Zinc,	11 Palladium,
3 Copper,	6 Platinum,	9 Iron,	13 Sodium.

14 Frozen Mercury.

The above metals are also ductile, or capable of being drawn into wire; but do not possess this property in the same order as their

malleability. Wire is manufactured by passing an oblong piece of metal through the progressive diminishing holes of a steel tool, called a draw plate. By this means wire of almost any length or diameter may be obtained, as the metal takes the size of the last hole through which it has passed. Silver, for the purposes of embroidery, is frequently made into wire one five-hundredth of an inch in diameter; and a grain of gold may be drawn into a wire five hundred and fifty feet long, by a process hereafter to be described. Platina wire has been obtained by Dr. Wollaston, so fine that thirty thousand pieces, placed side by side in contact, would not cover more than an inch. It would take one hundred and fifty pieces of this wire, bound together, to form a thread as thick as a filament of raw silk. Although platina is known to be the heaviest of known bodies, a mile of this wire would not weigh more than a grain, while seven ounces of it would extend from London to New York.

Platinum is a metal of a grayish-white color, capable of receiving a very high degree of polish. When perfectly pure it is extremely malleable and ductile; but the presence of a very small amount of foreign matter is sufficient to destroy these properties, and to render it both dull and brittle. The tenacity of pure platinum is nearly equal to that of iron, but ordinary commercial specimens almost invariably contain a certain proportion of iridium, by the presence of which this property is considerably impaired. This metal is infusible when exposed to the strongest heat of a wind furnace; but melts before the flame of the oxy-hydrogen blow-pipe, or between the charcoal poles of a powerful galvanic battery. Like iron it yields to the hammer, and admits of being forged and welded at a white heat.

Platinum is not attacked by any of the simple acids, but it readily yields to the caustic alkalies at a red heat, and particularly by lithia, though in no way affected by the alkaline carbonates, even when exposed to their action at a very elevated temperature.

When in an extremely divided state, platinum possesses certain remarkable properties, which render it of frequent employment in the chemical laboratory. When in this form it is known by the name of platinum black, and has then the property of

condensing, to a most extraordinary extent, the gases in which it is placed. In this way, platinum black which has for some time been exposed to an atmosphere of oxygen, will condense around it several hundred times its volume of that gas, and when brought into contact with certain inflammable bodies, causes their instant ignition. If, for example, a drop of absolute alcohol be let fall upon a small lump of this substance, which has thus been exposed in the presence of oxygen gas, it is at once inflamed, and the whole mass of the metal instantly becomes incandescent.

Platinum was not imported into Europe until the middle of the last century, although known for a long period previous to that time in America, under the name of *platina*, which signifies, in Spanish, *little silver*, and was even then, from the great difficulty experienced in working it, of comparatively little value. It is invariably found in a native state, and occurs in alluvial deposits similar to those from which gold is obtained. It generally presents the appearance of small flattened grains, of a grayish-white color, approaching that of tarnished steel. Their size varies from linseed to that of hemp seed; but a few fragments of much larger dimensions have occasionally been discovered. The Royal Museum of Madrid possesses a specimen, found in the gold mine of Condola, South America, which is as large as a turkey's egg, and weighs seventy-six hundred grains. The largest specimen yet discovered weighs twenty-one pounds, and is in the cabinet of Count Demidoff. The grains are separated from gold either by hand-picking or amalgamation. From an apprehension that this metal might be employed for the purpose of debasing gold, it was formerly thrown into the rivers, with a view of preventing fraud, by which means large quantities of this valuable metal have been lost.

Platinum is extensively employed in the manufacture of chemical instruments, and for the negative element in galvanic batteries. Large platinum vessels are likewise used by gold refiners, and platinum stills, for the concentration of sulphuric acid, have at the present day almost entirely superseded those of blown glass.

There is a great difference in the fusibility of metals. While

platinum, iridium, rhodium, and some others, require to be submitted to the flame of the oxy-hydrogen blow-pipe, potassium and sodium fuse below the boiling point of water. Tin melts at about 440°, Fahr., lead at 612°, and antimony at about 850°. Gold, silver, and copper, require a cherry-red heat; iron, nickel, and cobalt, fuse at a white heat; manganese and palladium are melted only by the strongest heat of a wind furnace; chromium, uranium, and some others, are but slightly affected when treated in the same way, while mercury retains its liquid form during the most intense cold of our climate.

Some of the metals transmit heat with greater facility than others, and are, consequently, well adapted for the manufacturing purposes where it is of importance that the heat acquired by the metallic surfaces should be readily communicated to surrounding bodies. Gold has this power in the highest degree; silver and copper follow in order; iron has the fourth place; and zinc, tin, and lead in order; but in the power of expansion under the influence of heat, lead surpasses both tin and zinc. All the metals are probably more or less volatile, although a certain number of them only admit of being readily converted into vapor at the highest temperature of our furnaces; such are zinc, cadmium, mercury, arsenic, antimony, tellurium, potassium, and sodium. Several others have the property of communicating characteristic colors to flames, and are therefore evidently volatile to a small extent.

Elasticity and sonorousness are attributes of the harder metals only, and are more conspicuous in some of their alloys than in the metals themselves. Steel and aluminum, in a pure state, possess both these qualities. The tone of aluminum is pure, and its vibrations are of an extraordinary duration. This quality has led to its use for bells, the tone of which is more agreeable than that of the finest bell metal.

Aluminum is the most remarkable of the more recent discoveries; unquestionably it is the most important of these, and on many accounts the most interesting. It was known to exist as far back as 1827, though all attempts to produce it in a metallic form failed till 1847. Even then it was supposed to exist only in

small quantities, and was esteemed rather as a curiosity than for any useful purposes; but it can now be produced without limit as to supply, and it will yet be so low in price as to take the place of iron and copper for many articles of daily use. At first the price was that of gold; now it may be had for one fourth that of silver: and as it is rapidly and cheaply produced, its market value will gradually diminish, and at the same time its qualities will become known, so that it will grow into favor.

Aluminum is named from its occurrence as one of the ingredients of alum. The most common clays contain about twenty-five per cent. of this metal, which, when obtained, possesses most curious properties. In color, it is tin-white; it is unaffected by the air, and is so completely inoxidizable that it resists the action of the air in a muffle heated to the temperature at which gold is assayed, and at a heat at which lead burns and litharge melts it remains unaffected. It is unattacked by any ordinary acid, except muriatic acid, which, and the alkalies, seem to be the only chemical enemies. It cannot be alloyed with mercury, and scarcely takes the least trace of lead. Electricity it conducts eight times better than iron, consequently as well as, if not better than, silver. It is very malleable, and when rolled and hammered becomes as hard as iron, a most invaluable quality possessed by no other metal in use; and as it melts at a lower temperature than silver, it possesses all the most valuable qualities required by the workman.

At first it was supposed that it would be impossible to alloy aluminum with any other metal, but recent experiments prove that it forms alloys with zinc, copper, silver, and tin. With copper it gives a very hard and white alloy, even where there is twenty-five per cent of copper in the mixture. These alloys are fusible in a greater or less degree, but all melt at a lower temperature than aluminum. The alloy with copper is extremely hard and brittle; it scratches glass, and can be fractured by a blow from a hammer.

But the most remarkable quality of aluminum is its lightness, in which respect it stands above all other bodies of the metallic class that are in use. The lightest of these is zinc, which

is seven times heavier than water; iron is nearly eight times heavier; silver is nearly ten and a half times, and gold twenty times; whereas aluminum is little more than twice and a half times as heavy as that fluid, and consequently it is only about one-quarter the weight of silver. An ounce of it will go as far as four ounces of silver or eight ounces of gold. Constant exposure and daily use have no effect on its brilliant surface, for it never tarnishes, and the time will probably come when it will be employed for articles of the most ordinary use. The supply will be inexhaustible, for every clay bank can be made to yield it; the qualities it is already known to possess will render it an object of attention, and commerce will look to it that the supply equals the demand.

All the metals may be made to combine with oxygen, although their affinities for this body are extremely different. Some of them combine with it at all temperatures, and can only be reduced to the metallic state with great difficulty; whilst others possess so little affinity for this metal that they cannot be made to combine directly with it, and a slight elevation of temperature is sufficient to effect a separation.

When a metal unites with oxygen, the combination is usually attended with heat; if the action be very rapid, combustion, together with intense light, is frequently the result. The combustion of the metals in oxygen gas goes on most rapidly when they are reduced to the state of powder previous to being subjected to its action, as in many instances the coating of oxide at first formed quickly prevents further change. For this reason a stout copper-wire, if heated to redness, and immersed in a jar of oxygen, rapidly becomes covered with a coating of oxide, which quickly protects the metal from further action; but if copper filings be treated in the same way they instantly ignite, and become converted into oxide of copper. If the oxide produced by the ignition of a metal in the gas is fusible at the temperature obtained by its combustion, it will be unnecessary to reduce it to powder, as the continual melting of the oxide constantly exposes a clean metallic surface to the further action of oxygen. For this reason, iron and steel, previously heated to redness, and

immersed in a jar of oxygen, burn with great violence, even when exposed in large masses.

The volatile metals, when similarly treated, burn with great rapidity, as the first application of heat gives rise to the production of vapors which are quickly consumed, and as rapidly replaced by another portion generated by the heat produced from the combustion of the first. Many of the metals may be kept indefinitely exposed at ordinary temperatures, to the action of perfectly dry oxygen without combination; but if moisture be admitted, chemical action is at once set up, and the metal rapidly oxidized. The polish of a bar of iron is not impaired by being kept in a jar of dry oxygen, but a moist atmosphere soon produces a deposit of oxide which rapidly increases, and finally destroys it. In the case of some of the metals, such as zinc, the coating formed is very superficial, and serves to protect its surface from further action. The oxidation of many of the other metals, on the contrary, goes on after a certain time has elapsed with greater rapidity than at the commencement of the action. This arises from the coating of oxide formed being in an electro-negative state with regard to the unoxidized metal, and a voltaic pair is thus established, which continues in action as long as there is any portion of unoxidized metal remaining.

The presence of acid vapors in the air very much accelerates the oxidation of the metals. When a piece of iron is acted upon by a humid atmosphere, it is attacked by oxygen dissolved in the watery vapor, and as the oxide of iron formed possesses a certain basic affinity for water, the action is thereby increased. In this way iron and zinc, which do not decompose water at ordinary temperatures, and may be indefinitely preserved in that fluid when deprived of its dissolved oxygen by boiling, are, by the addition of a few drops of sulphuric, or any other strong acid, rapidly attacked. The affinity of the metal for oxygen is thus increased, and the oxide formed at once combines with the acid present, giving rise to a soluble salt, which being dissolved in the water, constantly leaves a clean metallic surface to be in its turn converted into oxide.

The metals, with but few exceptions, are capable of combin-

ing with each other, and thereby forming a class of compounds possessing more or less the properties of their several constituents. Alloys are generally more fusible and harder than the metals which enter into their composition; and as these properties may be regulated according to the relative amount of the various metals employed, an indefinite number of modifications may be thus attained. Copper is very malleable and ductile, but is difficult to fuse, and for many purposes does not possess the requisite hardness. In many instances these defects may be obviated by the addition of one-third of its weight of zinc, which, without much impairing its malleability, renders it fusible, brightens its color, and at the same time communicates to it a proper degree of hardness. In the manufacture of cannon, a mixture is required not only sufficiently hard to withstand the friction of the shot during its passage through it, but also capable of resisting the corrosive action of the products arising from the combustion of gunpowder. It should likewise possess considerable toughness, without which the gun would be liable to burst. In many cases, and particularly for battery use, cast iron is used; but when guns are required to be moved from place to place, the brittleness of that metal becomes a serious objection, as, unless made very thick and heavy, they would not be capable of withstanding the explosive force to which they are subjected. If copper were employed, it would in the first place be extremely difficult to mould, as, from the high temperature required for the fusion of that metal, it is liable to chill and produce air holes in the casting; and in the second, would soon wear out, if made, from the rebound of the shot in passing from the breech to the muzzle during the discharge.

By the addition of ten parts of tin to ninety parts of copper, an alloy is obtained which answers all these conditions, and is also used under the name of bronze (to which due reference will be had hereafter), for the manufacture of statues, and for various other ornamental purposes.

For printing types, an alloy is required, at the same time hard and fusible, and which does not materially contract in cooling. Lead, which is a fusible metal, is evidently unfitted for

this purpose by its softness, whilst zinc and bismuth are too liable to break under the pressure to which the types are exposed in the process of printing. By combining, however, twenty parts of antimony and eight of lead, an alloy is produced which fulfils all these conditions, and furnishes us at a cheap rate with a material admirably adapted for the purposes intended.

It has long been a disputed question, whether the alloys are chemical combinations of metals in definite proportions or merely mechanical mixtures, without regard to their atomic relations. It is, however, probable that they are, in all cases, combined according to the laws of chemical affinity.

Alloys are generally more oxidizable than their constituents taken singly. This probably arises from the circumstance of one of the metals being electro-negative with respect to the other, by which means electric action is set up and the more positive metals oxidized.

The action of acids on alloys varies according to the relative amount of their constituents. Silver alloyed with a large quantity of gold is protected from the action of nitric acid, by which, under ordinary circumstances, it is rapidly attacked. Sometimes, however, the reverse of this takes place, and metals which are totally insoluble in certain menstrua, are made to dissolve in them by the addition of a metal on which they have the power of acting. In this way, platinum, although of itself insoluble in nitric acid, may be dissolved by it when sufficiently alloyed with silver. Alloys consisting of two metals, the one easily oxidizable, the other possessing a less affinity for that element, may be readily decomposed by the combined action of heat and air. In this cause the former metal will be rapidly converted into an oxide, except perhaps the last portion, which may, in some degree, be protected from further action by the oxide already formed. The increased affinity for oxygen exhibited by the more oxidizable metal, in presence of another less affected by this agent, is doubtless an electric phenomenon, and action is in many cases so rapid as to produce combustion. This occurs when an alloy of three parts of lead and one of tin is heated in contact with air.

Some of the less oxidizable metals are occasionally found in the malleable or native state, although the larger number even of those are commonly associated with one or more of the non-metallic elements, such as oxygen, sulphur, or arsenic. By far the greater portion of the metals are, however, met with in combination with one or other of the three elements above mentioned, and are then said to be mineralized. The resulting compounds are called minerals, and when these can be employed in the arts for the purpose of furnishing the metals which they contain, they are known by the name of *ores.* Thus a copper ore, or lead ore, means any natural combination of these metals with other bodies in such proportion that the resulting compound admits of being advantageously treated for the metal it contains. Many of the metallic ores, instead of being compounds of two or more simple substances, consist of natural metalliferous salts, and of these the carbonates, silicates, sulphates, and phosphates, are among the most common examples. Among the metals occurring in nature in a free state, are gold, platinum, rhodium, iridium, palladium, silver, copper, mercury, antimony, and bismuth. The following metals are almost invariably found in combination with other substances: manganese, iron, cobalt, nickel, chromium, tungsten, molybdenum, vanadium, zinc, cadmium, lead, tin, titanium, and uranium.

Although mineral substances are occasionally met with in the form of crystals, they occur with much greater frequency in the state of masses possessing little or no trace of crystalline arrangement. These massive minerals consist either of grains more or less minute, of leaves or laminæ, or of small columns or fibres. In the first case, the structure is said to be *granular*, in the second *lamellar*, and in the third *fibrous* or *columnar.*

When the structure of a granular mineral is rough, it is said to be *coarsely granular*, as in some varieties of marbles. When the grains are fine, it is *finely granular*, as in granular quartz; and if the grains are so excessively fine as not to be detected, the structure is said to be *impalpable*, as in the case of the chalcedony.

Minerals are possessed of four different kinds of fracture;

these are severally termed *conchoidal*, *hackly*, *even*, and *uneven*. When a substance breaks with a convex and concave surface, as in the case of the flint, its fracture is *conchoidal*. When the elevations are sharp and uneven, as in broken iron, it is *hackly*. If the surface is nearly flat, its structure is said to be *even;* and it is said to be *uneven* when the surfaces are subject to various elevations and depressions.

The surface of the earth is in many localities traversed by clefts or fissures, probably produced by great convulsions of nature which have occurred in remote ages. These are sometimes found to be filled by the trachytic or porphyritic rocks, by the injection of which the fissures were formed, whilst in other instances they contain various metals, either in a free state, or in different forms of combination. In the former case these formations are called *dykes*, but when they contain metallic ores they are called *mineral veins*.

Mineral veins are often nearly perpendicular in their direction, although they sometimes possess considerable inclination. Generally speaking, a vein may be regarded as a plane, of which the extension, in length and depth, is unknown, as the former is usually bounded by a contraction too small to induce the miner to follow it, and the latter is frequently greater than that of the deepest mine. It seldom happens that an isolated vein is found in any particular locality, and with but few exceptions where ore has been discovered, others may safely be inferred to be at no considerable distance.

It is often found that all the veins of the same locality have a nearly similar direction; and if two distinct systems of lodes should occur in the same neighborhood, those running in one direction, if metalliferous, yield a different metal from those which do not follow the same course. The veins containing the metallic ores are called *lodes*, and those which are not productive in metal, and are not in the usual direction of the lodes of the district, are *cross-courses;* the dip or inclination of the vein to wards the horizon is its *hade*, *slope*, or *underlie;* and its intersection with the surface constitutes what is called its *run* or *direction*. *Strings* are small filaments into which the vein sometimes

splits, and of these, those which are very small are sometimes called *threads.*

The composition of mineral deposits appears to be affected somewhat by the nature of the rock through which they pass, as certain minerals are found to exist in large quantities in the portion of a lode which passes through one kind of rock, whilst in another of a different composition they are either of unfrequent occurrence or entirely absent. As a general rule, those veins are found most productive which are situated in the immediate neighborhood of the junction of two different species of rock. In Cornwall, where a large portion of the mineral riches of Great Britain are extracted, all the most productive mines are situated near the point of meeting of the granite *killas*, or clay-slate.

Besides these more ancient formations of mineral ores, it sometimes happens that the valleys in the neighborhood of metalliferous rocks have, in the course of a long series of years, become partially filled by sands washed from the surrounding mountains, and which are found to contain a portion of the metallic riches of the hills of which they once formed a part. In some districts such deposits are extremely common, and afford, by washing, large quantities of various metals. In Cornwall, most of the valleys in the tin districts yield sands containing the peroxide of that metal. In the island of Banca, in the Eastern Archipelago, large quantities of tin ore are thus obtained, and the extent to which such operations are carried on may be imagined when it is stated that as much as thirty-five hundred tons of this metal have been annually exported from that island.

From long exposure to oxidizing influences, the ores thus obtained are perfectly free from sulphur and arsenic, and for this reason are exclusively employed in the preparation of the finer varieties of grain tin. In other cases, gold in the virgin state is distributed in small grains in these sands, and this is, in fact, one of the chief sources of that metal. The sifting and washing of such sands furnish to Russia nearly all the gold produced in that empire, which annually amounts to about fifteen thousand pounds weight. Russia also obtains by the same means an annual supply of nearly five thousand pounds weight of platinum, which

is almost entirely extracted from the streams flowing from the Altai mountains, which separate Siberia from Tartary. The gold that Africa yields is in the form of dust, gathered from the mountain streams; and from the sands of the mountain streams of California, the miners have washed an extraordinary amount of gold.

The mineral riches of a country are frequently discovered by attentively observing the fragments brought down by the action of water from the hills into the valleys; and on tracing these to their several sources, the veins from which they were originally detached, are, in many instances, found. Water also acts in another way a very important part in the disclosure of mineral veins, as by closely examining the faces of the different gullies and ravines, which intersect a country, a ready means is afforded of ascertaining whether its strata are traversed by metalliferous deposits.

If the substance of a mineral vein be harder than the rock in which it occurs, the latter is sometimes, by the alternate action of air and water, gradually removed, whilst the lode itself remains as a sort of natural ridge across the country. But when these means of observation are not available, it is necessary to examine the nature of a district through the medium of artificial excavations.

When a lode has been discovered, and is found to yield a metal, or presents appearances from which it may be inferred likely to prove productive at a greater depth, the first operation, if the conformation of the locality admits of it, is usually to drive an *adit level.* This is a gallery cut a little above the surface of the nearest valley, in such a way as to intersect the lode at a certain distance from the surface, and draw the water from the higher portion of the vein. Should the appearance of the vein prove favorable, a pit or shaft is sunk in such a position that it may intersect the lode at a proper distance from the surface, and serve as a means not only of extracting its minerals, but also of ascent and descent of the miners employed. For this purpose a windlass is mounted on the shaft, and is placed on a strong stage of wood, and by the aid of this and a long rope, two buckets

or *kibbles* are made to alternately ascend and descend in the pit.

The tools employed by the miner necessarily vary according to the nature of the rocks which he has to traverse. If the ground be moderately soft, nothing but an ordinary pick and shovel are used; but if it be hard, and is either stratified or contains numerous fissures, he has recourse to steel wedges or points called *gads*, by driving which into the crevices of the rock, he is enabled to split off larger portions than he could detach by the use of the pick alone. When the ground to be cut through does not admit of being thus broken, the working is effected by the assistance of gunpowder.

On reaching the surface, the ores are broken by large hammers, and divided into classes according to their relative richness in metal, whilst the unproductive portions are picked out and rejected. Few ores contain so large an amount of metal as to render their concentration by mechanical means unnecessary.

In order to reduce the fragments of mineral ores, and particularly those of copper, to a proper size for their subsequent mechanical concentration, large cylinders of cast iron, moving in contrary directions, are frequently employed. The ore to be crushed is allowed to fall gradually between the two rollers, through a hopper, and on passing through, the crushed ores fall into the higher extremity of an inclined cylinder of coarse wire gauze, where it is properly sifted. Many minerals, and especially the ores of tin, instead of being crushed by rollers as above described, are pounded into small fragments by large pestles, moved either by water or steam power.

Thus prepared, the ores are repeatedly washed till all the worthless matter is removed, and having been roasted, to expel the sulphur and arsenic which they may contain, they are passed through two distinct operations—the reduction of the oxide to the metallic state, and the separation of the earthy matter in form of scoria.

CHAPTER II.

IRON.

OF all the metals that man has drawn from the earth, and appropriated to his own use, that to which we now call attention must unquestionably take rank; for on iron we depend for articles beyond number, and all of which are essential to our comfort and convenience; and were we called upon to forego the use of it, there can be no question but that all the metals designated as "precious," would be cheerfully resigned, if this alone were spared to us.

When iron was first dug from the bowels of the earth and converted into instruments of the chase or domestic utensils, we have no means of knowing, for the early history of the world is wanting in such details. To kill a man with an instrument of iron was punishable with death under the Mosaic law. Moses has recorded of Og, king of Basan, that he had a bedstead of iron, that was nine cubits in length and four in breadth. And when he reminded the Israelites that the Lord had brought them out of the iron furnace, even the land of Egypt, he promised to bring them into a land whose stones were iron, and out of the hills they might dig brass. The Greeks ascribed the discovery of iron to themselves. The Romans knew not how to provide their iron furnaces with bellows, and, to ignite the fuel, placed the grate in the direction of the prevailing wind. As a substitute for it in their armor, they employed bronze. The more northern nations used iron, but sparingly; their weapons were

made of copper, and even of gold, with a thin strip of iron attached to form a cutting edge. Cæsar, when he invaded Britain, found the inhabitants in the possession of rings and money of iron, but who shall say whether the iron was of their own forging, or was received from the Phœnicians in barter for tin ? The Hottentots have long understood the art of smelting both iron and copper, in a conical furnace of clay. Iron ore is found in Africa in immense quantities; and in their rude way, the untaught natives form various useful and ornamental articles, such as spears, arrowheads, knives, armlets, bracelets, &c., and a small but regular amount of this important material, made into a peculiar shape and called a "bar," appears to be the standard of value by which their currency is regulated.

In England, iron was first cast in Sussex, in 1543. In 1740, the total amount of iron produced in England, was 17,350 tons. At that time the annual product of Europe was about 100,000 tons, 60,000 of which came from the furnaces of Sweden and Russia. Now Great Britain produces annually 3,585,000 tons, and the whole product of the world may be set down at 7,000,000 tons, of which the United States produce one-seventh.

A bar of iron, valued at five dollars, worked into horseshoes, is worth ten dollars and a half; into needles, three hundred and fifty-five dollars; pen-knife blades, three thousand two hundred and eighty-five dollars; shirt-buttons, twenty-nine thousand four hundred and eighty; and balance springs for watches, two hundred and fifty thousand dollars. Thirty-one pounds of iron have been worked into wire one hundred and eleven miles in length, and so fine was the fabric that a portion of it was converted, in lieu of horse-hair, into a barrister's wig.

The usefulness of iron is thus set forth by Edward Everett: "I have now in my hand a gold watch, which combines embellishment and utility in happy proportions, and is often considered a very valuable appendage to the person of a gentleman. Its hands, face, chain, and case, are of chased and burnished gold. Its gold seals sparkle with the ruby, topaz, sapphire, emerald. I open it, and find that the works, without which this elegantly furnished case would be a mere shell—those hands motionless,

and those figures without meaning—are made of brass. Investigating further, I ask what is the spring, by which all these are put in motion, made of? I am told it is made of steel! I ask what is steel? The reply is that it is iron which has undergone a certain process. So, then, I find the main-spring, without which the watch would always be motionless, and its hands, figures, and embellishments, but toys, is not of gold, (that is not sufficiently good,) nor of brass, (that would not do,) but of iron. Iron, therefore, is the only precious metal! and this watch an emblem of society. Its hands and figures, which tell the hour, resemble the master spirit of the age, to whose movement every eye is directed. Its useless but sparkling seals, sapphires, rubies, topazes, and embellishments, are the aristocracy. Its works of brass are the middle class, by the increasing intelligence and power of which, the master spirits of the age are moved; and its iron main-spring, shut up in a box, always at work, but never thought of, except when it is disorderly, broken, or wants winding up, symbolizes the laboring class, which, like the main-spring, we wind up by the payment of wages, and which classes are shut up in obscurity, and though constantly at work, and absolutely necessary to the movement of society, as the iron main-spring is to the gold watch, are never thought of except when they require their wages, or are in some want or disorder of some kind or other."

Iron is now relatively one of the cheapest of metals, costing from about a cent a pound in its crudest and lowest state (pig iron), at the point of its cheapest production, up to five or six cents a pound for its purest and rarest qualities. In its refined and carbonized form of steel, it was not long since worth twenty-five cents per pound, at retail, in this country; but the cost of the steel-making process has been rapidly reduced by recent discoveries and improvements, until steel is hardly double the value of the better qualities of iron. New steel-making processes—several of them originating in this country—have recently been patented, and are now being reduced to practice, by which it is believed that the price of steel will be still further reduced, and the quality essentially improved.

Iron, we know, is a metal of a bluish-gray color and fibrous fracture, receiving, when polished, a brilliant surface. It possesses greater tenacity than any known metal, and is at the same time the hardest of those which are malleable and ductile. The iron of commerce is not, however, chemically pure; for, besides containing variable qualities of carbon, traces of silicium, sulphur, and phosphorus may be detected. The presence of these substances materially influences the quality of the metal, and therefore for objects requiring great nicety of construction the purest varieties are alone employed.

The texture of commercial iron varies according to the nature of the process to which it has been subjected during its preparation. A piece of iron which has been hammered equally in every direction will, on being broken, be found to have a finely granular structure; but when it has been drawn into long bars, in which form it usually comes into the market, the texture will be invariably more or less fibrous in the direction of the length. This silkiness of appearance is most distinct in the better varieties of iron, and its structure is therefore one of the best indices of the quality of the metal. By skilful management this peculiarity may, however, be in a certain degree imparted to the commoner varieties, and it is, consequently, unsafe from this circumstance alone to judge of the quality of iron. It is also found that the most fibrous varieties do not retain their peculiarity of structure for an indefinite time, but that after a certain period the grain of the metal often assumes a crystalline appearance. These changes are most frequently observed to take place in the tension rods of suspension bridges, and in other situations where the metal is subject to constant vibrations. The same effect is also produced by friction, and for that reason the axles of locomotives and railway cars are often found to acquire a crystalline structure, and are therefore rendered harder and more brittle than the metal from which they were originally made. The experiment of heating strongly in a forge specimens of iron so changed, and cooling them slowly under a bed of sand, has proved successful. Metal that crumbled under blows from a hammer, has been found to be perfectly fibrous after passing through a forge.

In order to melt iron, the strongest heat of a wind furnace is required; but when combined with a small proportion of carbon, its fusion is more readily effected. On cooling, it assumes a pasty consistence before taking the solid form, and it is therefore extremely difficult to obtain it in a crystallized state. When, however, large masses are allowed to cool very slowly, distinct indications of a cubical crystallization are obtained. At a full red-heat, iron may be hammered into any required form; and on being heated to whiteness, two fragments may be firmly joined together without the aid of any kind of solder. This operation, which is called *welding*, is effected by heating two pieces of metal until the exterior is in a semi-liquid state, and then quickly uniting them by repeated blows from a heavy hammer. Considerable experience is requisite in order to effect this object; for, on heating iron to the requisite temperature, it becomes externally coated with a layer of oxide, which would effectually prevent the union of the two fragments if not previously removed.

To prevent the formation of much oxide, as well as to combine with that unavoidably produced, a little silicious sand is often sprinkled on the ends of pieces which are to be united, before they are placed in the fire. This has not only the effect of combining with any portion of oxide that may be found, and thereby removing it from the surface of the metal, but the silicate of iron thus produced forms a kind of varnish which effectually preserves it from any further action of the air. On withdrawing the bars from the fire, this is, by a rapid motion of the mass, shaken off, and two perfectly clean metallic surfaces are thus brought together.

If a mass of iron be either brought in contact with, or placed at a short distance from a natural or artificial magnet, it becomes itself magnetic, but loses this property when the exciting magnet is removed. When iron is combined with a certain amount of carbon, it is known by the name of steel. This substance is much less susceptible of the magnetic influence than ordinary iron, but when once the power has been communicated, it is retained for a considerable time after the removal of the magnet from which it was acquired. Permanent magnets may be ob-

tained by rubbing a bar of steel either with a loadstone or an artificial magnet, and in this way an infinite number of steel bars may be rendered magnetic without at all diminishing the power of the bar by which the effect has been produced. The magnetic power of iron is much influenced by its "temperature," as the magnetic needle is but little affected by a mass of that metal when made red-hot, but in cooling it will be found to gradually regain its magnetic powers.

Iron may be indefinitely exposed to the action of dry air, or even of dry oxygen gas, without becoming oxygenized; but if the air or gas contain any portion of watery vapor, the surface of the metal quickly becomes coated with a layer of rust. This is produced by the oxidation of the surface of the metal when exposed in a moist atmosphere. The formation of oxide is also much accelerated by the presence of carbonic acid, of which a certain portion is always present in the air.

When iron is strongly heated and exposed to the air, its surface is quickly coated with black oxide, which, on being struck with a hammer, easily scales off. It is this property of iron which causes it to afford sparks when struck with a flint or other hard body. Under these circumstances, small particles of iron are torn off by the flint, which produces sufficient heat by friction to render the particles of the metal incandescent on combining with the oxygen of the air; and by allowing these heated particles to fall on an easily ignitable substance, such as tinder, a fire is obtained. If, instead of tinder, a piece of paper be held beneath the metal during the time it is being struck by the flint, its surface soon becomes covered with small fragments of black oxide of iron, fused into minute globules, and readily attracted by the magnet.

Bars of iron, kept in a vertical position, or at an angle of 70° to the horizon, become magnetic spontaneously. They may also be magnetized by percussion, or an electric shock, either from a common machine or a thunder cloud.

For the purposes of the arts, iron is invariably obtained from the native carbonates and oxides of that metal. The first state in which it is presented to us when obtained from the ore, is in

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its combination with carbon, by which it is rendered hard and brittle. Under this form its valuable properties are not observed, and it is probable that it was first known to man in this state. Large masses of metallic iron are occasionally found on the surface of the soil in different parts of the globe, whilst others of similar appearance have from time to time been observed to fall from the atmosphere in the meteoric form. Meteoric iron is chiefly composed of iron and nickel, the latter varying from two to ten per cent., with small quantities of cobalt. Science has made meteoric iron, and it has been tested. Its qualities have been found identical with those of native compound. Meteoric iron is more ductile, and has more tenacity than pure iron, and is not so liable to rust or oxidize.

The existence of iron in a native state was for a long time a matter of dispute among mineralogists; but it is now generally admitted that, although of rare occurrence, specimens of native malleable iron have been discovered. In our Western States, there are masses of iron—mountains they are not inaptly called—of this metal, almost in a pure state.

Iron ore is distributed all over the globe, at various depths below the earth's surface, and there is quite as great a difference in the quality of the iron when reduced to a metallic form. Considered in a purely mineralogical point of view, without reference to their importance for reduction, they may be reckoned to be nineteen in number, of which ten are worked by the miner either for the sake of the iron which they contain, or for extracting some principles from them advantageous to the arts and manufactures, such as arsenical iron, sulphate of iron, sulphuret of iron, and chromate of iron.

Iron is employed in three different states—as crude or cast iron, as steel, and as wrought iron. The difference existing between these three substances essentially depends on the relative amounts of combined carbon with which the metal is associated. Cast iron contains a larger proportion than steel, and steel more than wrought or malleable iron, which ought to consist of pure metal without the slightest trace of carbon. In practice, this state of perfection is never obtained; but the more esteemed

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varieties are only found to retain extremely minute portions of carbon.

As already stated, many kinds of ores require to be roasted before they are treated for the metal they contain ; by this means the water and carbonic acid present are expelled, and the ore reduced to a porous state extremely favorable to the process of smelting which it undergoes.

To effect the calcination of ore, it is piled in long heaps over a stratum formed of large lumps of coal. The fire is applied at the windward end, and after it has burned a certain distance, the heap is prolonged with the same material in an opposite direction. The ordinary height of the heap varies from about six to seven feet, while its breadth at the bottom is about fifteen or twenty feet. The roasting of iron is likewise frequently conducted in furnaces resembling ordinary lime-kilns, and in which its calcination is effected in the same way.

There are six descriptions of iron that come from the furnace in which the ore is melted. The first is called *foundry iron*, and contains much carbon. This combination makes the metal very brittle, but it is well adapted for castings, as it becomes very fluid when melted, and will run into the finest and most delicate moulds. It is used for small ornamental castings, and any thing that requires a minute and perfect adaptation to the shape of the mould. It is distinguished in its appearance by great smoothness on the surface of the pig, and in the fracture it exhibits a large dark bright and open grain, intermixed with dead spots of lighter color and closer texture.

The next variety is also known as *foundry iron ;* it has less carbon and is closer grained. It is not so fluid when melted, nor so smooth on the face of the pig. It is, however, harder and stronger, and is preferred where strength and durability are required.

The next, from its appearance, often called *dark gray iron*, has still less foreign admixture in its composition, and is used indifferently for the forge and the foundry, particularly in situations where it is to be exposed to constant wear and tear, for which its toughness and hardness admirably fit it.

Bright iron comes next in order, and it is used exclusively for larger castings. It possesses great strength, but not fluidity enough to adapt itself to intricate or minute mouldings, and it derives its name from its bright lustre.

Mottled iron is used exclusively for the forge, as it is wholly unsuited to the wants of the foundry. It is smooth in the face, hardly exhibiting any grain, and appears to be composed of two qualities imperfectly combined, hence its name.

White iron is supposed to contain a very small portion of carbon. It is totally unfit for castings, and is so thick as hardly to run into the pig moulds, and so brittle that the largest pig may be readily broken by a blow with a sledge hammer. It is too hard to yield in any degree to the chisel, and when broken the color of the fracture is silvery white.

All these six descriptions contain oxygen and carbon, and it will be seen that, so far as the carbon is considered, the purer the iron is when it runs from the furnace, the less fitted for foundry purposes.

The process consists in separating a portion of the carbon from the pig, and then reducing the iron to a greater degree of purity, preparatory to the subsequent operations it must undergo. This is effected by keeping the pig in a state of fusion for some time, exposed to a very great degree of heat, in a strong blast furnace prepared for the purpose. When cooled, it is taken to the puddling furnace, where the oxygen and carbon are still further and more carefully separated than could be accomplished in the refinery. In about half an hour the pieces of metal begin to melt, and when the whole is reduced to a fluid state, the puddler (the name given to the workman) stirs it about in all directions, exposing every part in turn to the action of the flames. The mass heaves and boils, showing the escape of an elastic fluid, and when it has passed through this stage it begins to thicken till it is in a state that allows the puddler to form it into lumps, which are called puddler's balls or blooms. From the puddler, the blooms pass to the shingler, who gives them a few blows with a hammer, weighing from six hundred to twelve hundred pounds, worked by machinery, to make them more solid; or, they go

directly to the rollers, where each bloom is passed between the cylinders called *rolls*, entering the largest hole first, and each in succession. The bloom, as it comes out on the opposite side, is received by a boy, who places the end to the second and next sized hole, through which it passes, and so on, till it is reduced by being elongated to the proper size.

The iron is now in the shape of a bar, rough and imperfect on its edges, scaly and uneven on its surfaces, and unsound in the body, and therefore not yet calculated for the smith's use. Another process these bars must undergo. The first step is, to trim the ends, and cut them into proper lengths, which is done by a strong pair of shears, worked by the engine. Then they are taken to a reverberatory furnace, heated by a coal fire at the end, in which they are stacked up with care, and heated. In the furnace, by the action of the flames, all the corners and sharp edges are worn off or rounded, and at the proper moment they are withdrawn in succession and passed through the finishing rolls, which give to the bars their respective size and shape—round, flat, or square. Then they are straightened on a long bench of cast iron, by boys, who stamp them, and the ends are again trimmed by powerful shears.

A great improvement in the manufacture of iron has been brought forward by Mr. Bessemer, in England, who claims the discovery of a process by which the ore is reduced to wrought iron at one heat, and at a great saving of expense, while the iron thus produced is superior to that obtained by the ordinary method. But the process employed is no improvement over that in use in the United States some years in advance of Mr. Bessemer's discovery. The American process consists in adding to the pig-iron placed in the puddling furnace, such a proportion of oxide of iron that the oxygen of the ore shall exactly suffice for eliminating the carbon of the pig metal as carbonic oxide, or carbonic acid. This proportion, the editor of the Annual of Scientific Discoveries believes to be, fifteen parts of ore to one hundred of pig-iron. The whole is melted up together in the puddling furnace. The oxide at first acts as a flux, but is gradually reduced to pure metal, giving up its oxygen to the carbon of the pig metal. When

the operation is complete, the iron master finds that he has not only obtained a perfectly fibrous iron without loss, but for every one hundred pounds of pig metal put into the furnace, he draws out an average of one hundred and five pounds of fibrous iron.

Mr. Bessemer's process consists in making the fuel already combined with the iron in the blast furnace, do the work which is commonly thrown upon the puddling furnace. He has a cylindrical vessel pierced with holes for the blast, and having other openings through which to charge and tap the metal vat. This is so placed that the molten metal from the blast furnace can flow into it. Through the metal, while still glowing, a current of air is passed. A violent boiling takes place in the melted iron, and flames and sparks rise from the vessel. The heat is greatly increased; the combined carbon begins to separate from the metal, burning off in an immense flame. As the carbon diminishes, the oxygen of the blast combines with some of the iron, forming an oxide which every metallurgist knows to be a powerful solvent of silica. Scoriæ are consequently found, not upon the surface, but throughout the melted mass. The violent ebullition so mixes up the contents of the crucible that these fusible scoriæ are disseminated through the mass. Being lighter than the metallic iron, they rise to the surface and boil over, carrying with them the silicious matter diffused through the mass, and washing the metal clean. The pure iron, fused by the intense heat, is tapped out into the ingot moulds ready to receive it.

Another improvement made in England in the preparation of pig-iron, consists in the introduction of one and a half or two per cent. of common salt into the coke ovens along with the coals. The salt removes the sulphur from the coke, and hence the iron made with this coke in the blast furnace is materially improved.

And an improvement brought about in Scotland, in the same branch of industry, consists in conducting the coal gas that escapes from the mouth of the furnace and bringing it by flues underneath. Two hundred and forty-five tons a week were turned out in this way in one week, against one hundred and eighty tons by the old process; and the saving in the amount of coal was nearly fifty per cent.

Within the past few years an immense saving of coal has been effected in some iron smelting establishments, by conducting the waste heat of the blast furnaces under boilers to generate steam for driving the machinery employed.

The venerable Dr. Nott, says the Scientific American, was the first inventor who attempted to save the waste heat of blast furnaces, and apply it usefully, and his invention has now come into general use. Hitherto, however, the application of the waste gases of such furnaces has been defective, owing to the difficulty of making the hot gases descend from the top of the blast stack under steam boilers placed on the ground, thus rendering the system almost inapplicable to iron works built on level ground. This difficulty has been entirely obviated by the improvement in blast furnaces, for which a patent has been issued to Henry Weissenborn, of New York.

By Mr. Weissenborn's invention the hot gases of the blast furnace are stored up, in a reserve gas chamber, and made to descend easily from the top of the blast furnace under boilers placed on level ground. This improvement is not merely theoretically good; it has been practically and successfully applied at the Eurioka Iron Works, Wyandotte, Mich., where the gas is made to come down, without extra fans, under the boilers, and into the hot blast, and during an experiment of twenty-one days, at no time was all the waste heat used for generating the steam and heating the blast. Thus the whole cost of fuel for driving the steam engine in these iron works has been entirely saved by this improvement; and every invention which economizes waste in fuel is of vast importance to the iron interests of our country.

CHAPTER III.

MOULDING FOR CAST IRON.

CAST iron was first known in England in the twelfth century. At the present day there is no metal more generally used, and none that has been more abused when employed for ornamental purposes. Familiarity, in this as in every thing else, breeds contempt, and we have treated this metal with so much indifference that we have now reached a point which almost forbids the encouragement of the really beautiful, in the application of so humble a material to our daily wants. To this subject we shall hereafter call attention, and at present will confine ourselves to the foundry where all castings are made.

The foundry consists of a workshop for preparing patterns, a vast area, called properly the foundry, in which the moulds are made and filled with the molten iron; blast furnaces, capable of melting speedily the quantity of iron to be employed each day, a steam engine, smith's forge, &c., &c.

The metal obtained from the blast furnace is sometimes directly conducted to the moulds, where it is to receive the form under which it is to be employed; but for the better kinds of castings, and particularly when their weight is not very considerable, the metal is first run into pigs, and afterwards re-melted in a furnace called a cupola, from which the fused iron is subsequently drawn off into moulds prepared for its reception.

The best irons for the purpose of casting are those belonging

to the first and second class, as the white varieties are so extremely brittle as to render them unfit for the purposes of the founder. The iron best adapted for casting directly from the crucible of the furnace is that known by the name of gray iron. This iron is fine in the grain, and contains but a small proportion of graphitous matter, which would, if present, tend to render the metal porous, and materially detract from its strength. The iron produced by furnaces heated by wood charcoal is, when the mineral treated is tolerably pure, invariably well calculated for casting; but when coke is employed, various precautions are necessary to be observed in order to obtain satisfactory results. In this case both the ore and the fuel are liable to contain substances prejudicial to the quality of the metal, and it is therefore necessary to use a large proportion of flux, and to employ coke prepared from coal containing but little iron pyrites.

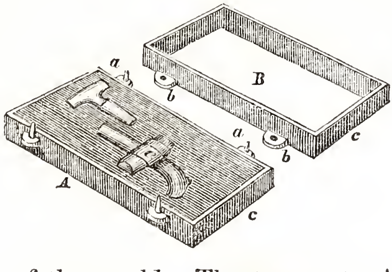
The mould into which the iron is poured should not only in every respect resemble in form the object to be produced, but also possess sufficient solidity to admit of the liquid metal being poured into it without changing its dimensions; and it should, moreover, be sufficiently porous to allow of the escape of the air contained in the cavities, as well as of the combustible gases generated by the action of the fused metal on the carbonaceous matter present.

The moulds for large castings are heavy, consisting of two, and often several, parts, which are moved by means of cranes, and the melted iron is usually transported from the furnace to the mould in the same way. The moulds are made of green sand, baked sand, or loam. The sand itself should be a kind of loam, possessed of a sufficient portion of argillaceous matter to render it moderately cohesive when damp.

When green sand is used, it is passed through a fine wire sieve, and mixed with about one-twelfth its bulk of finely powdered coal, and when slightly moistened and worked together it forms a porous compound, capable of preserving the form of the object impressed upon it. When the mixture has once been used it cannot be employed again, except for the coarsest castings, and is generally reserved for filling up the bottoms of fresh moulds.

The mechanical process employed in the preparation of moulds in baked sand are precisely similar to those used with green sand. Baked sand is, in the majority of cases, used without any admixture of coal dust; and after the completion of the mould, it is at once removed to a kind of oven, or drying kiln, where it remains until the moisture is entirely removed, when the metal is run in while the sand is hot. Castings made in this way are less liable to imperfections and air-holes than those prepared in ordinary green sand, as, from the porous nature of the material, the gases have greater facilities of escaping; and as the mould is kiln-dried before the introduction of the metal, there is less chance of its becoming chilled than by the other method. In all these manipulations, however, the success of the several operations must in a great measure depend on the skill and discrimination of the moulder, who should not only produce in the sand the exact counterpart of the object to be made, but, by a judicious mixture of his materials, so adjust his moulds that they may possess a considerable degree of tenacity, and also, at the same time, to be sufficiently porous to admit of the escape of the gases which are generated on the introduction of the liquid metal.

To mould an object in sand, it is necessary to be provided with an exact model of the article to be cast. This may be made either of wood or metal, but, from not being liable to warp or shrink, the latter is generally preferred. Besides the model, or pattern, the founder employs a peculiarly constructed cast iron box (see cut), which admits of being readily separated into two parts. In addition to its perpendicular sides, *c*, this box, or *flask*, as it is technically called, is, when of large dimensions, frequently provided with a series of cross-bars, which support the sand and add greatly to the solidity of the mould. The two parts, A and B, of the flask may be easily separated from each other, being merely held together by the pins, *a*, and the corresponding



holes, *b*, which serve not only to keep the two halves always in the same relative position with regard to each other, but also afford the means of firmly joining, by the aid of suitable keys, the two portions of the flask.

In order to obtain the form of any given model, the moulder places the part B of the flask on a platform on a level of the foundry floor, and having inverted it so that the crossbars, when there are any, may be uppermost, he fills it with sand, which he forces, by the aid of a rammer, through the spaces left between them. When this has been done, the half box is again turned, and as the sand with which it is filled, and which is retained in its place by friction against the sides and bars, has been strongly pressed against a smooth surface, it will necessarily itself take the same form. The workman now takes the pattern, *e*, from which the casting is to be made, and after having scraped a cavity roughly resembling the object to be moulded, in the smooth surface of the sand, the model is as nearly as possible imbedded to one-half its thickness. The whole is now slightly sprinkled either with charcoal dust or fine sand, which is found to prevent the adhesion of the two parts of the mould in the next operation.

The part, A, of the box is now lifted in its place, and is maintained in its position by the pins, *a*, entering into the holes, *b*, of the part B. The upper frame is then filled with sand, which is well and carefully rammed down, and as soon as this is accomplished, the box is turned, so that the frame, A, is placed under, and the part, B, is cautiously lifted in a vertical direction, and the two halves are again separated. The lower half, A, will now contain the pattern just half imbedded in the sand, which is generally found to fit very closely around the sides. As, however, perfect contact in all the parts is seldom thus obtained, the moulder consolidates the sand in the immediate neighborhood of the mould by first squeezing water on it from a wet rag, and afterwards pressing it down with a small trowel. When this has been done, the support of sand prepared in the first operation is destroyed, and the flask and its contents presents the appearance represented in the woodcut. At this stage of the operation, the part, B, of the box is again replaced, and after the surface of the sand con-

tained in the lower half, A, has been again dusted to prevent adhesion, the upper part is filled with sand, well rammed in as before.

In order to make the model separate readily from the sand in which it is imbedded, it is necessary to give it a few gentle taps with some hard body, since, if this precaution were neglected, the mould, on the removal of the pattern, would present a ragged appearance, from having adhered in some places to the model around which it has been pressed. After the model has been removed, any slight imperfections in the impression are carefully repaired by the use of a little moistened sand, which is applied with iron trowels of various shapes and dimensions. If the two parts of the flask be now joined by means of the projecting pins and their corresponding holes, it will evidently contain a cavity exactly corresponding in form to the object to be produced in metal, but before the casting can be commenced, it is necessary to prepare proper openings for the introduction of the liquid metal, and the escape of the enclosed air as well as the vapors generated during the operation. If but one aperture were employed to effect these objects, the air could only make its escape through the same opening by which the molten metal is introduced, and the casting would consequently be subject to imperfections from portions of the former being retained in the mould. the vapors would also not have proper facilities for escape, and violent and dangerous explosions would be liable to ensue. To obviate these inconveniences, at least two orifices are made in every mould, into one of these the melted metal is poured, whilst the gases and vapors evolved from the sand find vent through the other. In order to facilitate the escape of the air, the sand itself is rendered porous by being pierced by the aid of a wire with numerous small holes, extending to within about an inch of the mould.

When an article to be cast is hollow, the outer surfaces are obtained in sand as above described, and the interior cavity produced by suspending in the proper position, by wires or other contrivances, an exact model of the vacancy which is required to be produced. This model, or *core*, is generally made either of

clay or loam, and when of large dimensions, is supported by an iron centre, and rendered more tenacious by the addition of chopped hay, or some other cheap filamentary material.

Iron pipes were originally cast horizontally in moulds of sand, the preparation of which was a work of much time and care. They are now cast upright, in a mould sunk in the ground, and the labor attending the process is in some measure reduced.

Some years ago, an ingenious inventor patented in England a method of manufacturing iron pipes, or pipes of any metal, not so much by casting as by a species of churning. Only a single mould was wanted, and that, instead of having to be renewed for each pipe, was available for an indefinite number. The mould was, in fact, a cylinder, made to revolve at the rate of some thousands of times a minute, by means of steam power applied to proper machinery. By a stop-cock the molten metal was projected into the cylinder through the shaft upon which it revolved, and deposited it to any required thickness upon its interior by the rapidity of the revolution. The contracting which ensued on the cooling of the metal, enabled the workmen to withdraw it from the mould, which was rapidly cooled by artificial means and employed in the same way again. Pipes made by this process were found to be much closer in texture, and therefore much stronger than those cast in the usual way, and it was calculated they would bear double the hydraulic pressure of ordinary pipes. But notwithstanding the completeness of the machinery, from some unaccountable cause the invention has never been worked successfully to any great extent.

Moulds of loam are made directly from drawings of the object to be produced, as from the nature of the material employed, the use of patterns becomes unnecessary. The mould is formed from a mixture of clay, water, sand, and cow hair, which, after having been reduced to a state of a hard paste, and thoroughly kneaded in a loam mill or pug-tub, is, by the use of proper instruments, made to assume the form required. This method of casting is chiefly employed for the manufacture of hollow vessels, such as boilers, sugar pans, and lead pots, in which the thickness of the metal is very inconsiderable when compared with the other di-

mensions of the castings. The preparation of a loam mould is, in many instances, a complicated operation, as the workman has frequently to model a considerable portion of the work without an sort of guide except his own correctness of eye, by which to regulate his tools.

When castings with particularly hard surfaces are required, metallic moulds are sometimes employed, as from the rapidity with which these lose their heat, the iron poured into them is found exteriorly to acquire a peculiar hardness. Cannon balls are sometimes cast in moulds made of cast iron, and, to prevent the melted metal from adhering, the inside of the mould is covered with black-lead. This method is called *chill-casting.*

Sometimes it is found convenient to mould and cast one part of a design first, and then mould it with the other part, so that the two will be incorporated at the next casting. Wrought and cast iron are often brought together in this way, particularly for wheels, in which it is necessary to have spokes of great strength. These are of wrought iron, and when placed in the sand the end of each spoke projects into the hub and rim, the melted iron is then poured in to form the rim and hub, and the whole becomes a perfect wheel of great strength, and compact in the highest degree.

The patterns used in the foundry are usually made of wood, and metal; and plaster of Paris is also frequently employed, particularly for works of a high order, and which require to be wrought out with great delicacy. Iron is known to shrink in cooling, and it is therefore necessary to have the pattern somewhat larger than the article, when cast, is intended to be. The shrinkage amounts to about one per cent., and to correct it the workman is supplied with a contracting rule, made like a surveyer's rod, but one-eighth of an inch longer in the foot than ordinary standard measure. But when a wooden pattern is to be made, from which an iron pattern is to be cast, two shrinkages must be allowed for, and a rule one-quarter of an inch longer in the foot is required.

For melting cast iron, in a small blast furnace, called a cupola, is employed. These cupolas vary in size according to the quan-

tities of metal they are destined to melt at one time, but the same principles of construction are in all cases invariably observed. The furnace consists of an iron casing, internally lined with brick or argillaceous sand, and is supplied with air by one or more tuyers, or conical tubes, connected with a rapidly revolving fan. The diameter of the nozzles of these varies from three to five inches, and the vanes of the fan which supplies the air, make from six hundred and fifty to nine hundred revolutions per minute.

When the furnace is first lighted, no metal is thrown into it until a considerable accumulation of ignited coke has taken place in the bottom. Coke and pig-iron are then ultimately charged in the proportion of twenty-five of the former to every one hundred parts of the latter. The iron must, before its introduction into the furnace, be broken into pieces varying from fifteen to twenty-eight pounds in weight, and the first charge generally begins to melt in twenty minutes after it has been thrown in. The successive charges are made at intervals of from ten to fifteen minutes, but this is more or less influenced by the dimensions of the apparatus, and the quality of the metal which is being fused. When the fusion is complete, the clay plug, which closes the mouth of the furnace, is pierced with a pointed iron bar. The molten metal pours out, and is transferred from the cupola to the moulds by two different methods. For large and heavy castings, the moulds are often sunk in the floor of the workshop, and conveniently near to the cupola; the liquid iron is then led to it by means of channels formed in the sand. But when the moulds are small, and are situated at a considerable distance from the melted iron, it is drawn into large ladles, which are lined with loam, and carried by the founders to the place where they have prepared the moulds to receive it.

During the intervals which occur between the successive castings, the tap-hole is closed by a plug of damp clay. When a heavy casting is to be made at a considerable distance from the melting furnace, larger ladles of the kind above described are employed, and these are lifted and carried to the place of their destination by means of cranes or other machinery.

FIRE-GRATE—(IRON CASTING.) p. 21.

Every casting requires considerably more metal to be melted than is necessary to fill the moulds. The excess goes to form the gates, false seams, &c., which are removed after the cooling of the iron, and before the castings are sent out of the foundry. Besides this, there is always an actual loss of about six per cent. of the whole metal employed, so that, after deducting all these several items, each cwt. of coke thrown into the furnace is found to melt about three cwt. of ordinary pig-iron.

And here we cannot do better than insert an account of the Novelty Works, New York, which appeared in the Evening Post of that city, in 1850, and was subsequently copied into the Merchants' Magazine, with some additional particulars:

"As a subject that little has been written upon, we append a description of one of the largest iron manufactures in the United States—the Novelty Works, belonging to the Messrs. Stillman, Allen & Co., whose names are so closely connected with the great triumphs obtained in the recent construction of our largest ocean steamers. A visit to this extensive establishment will convey some idea of iron manufactures in general. Where this giant concern now stands was, a few short years ago, an unimproved point of land jutting into the East River—the favorite resort of the sportsman, who pursued his favorite amusement here unmolested. It is now, however, quite a populous locality, and the busy haunt of industry.

"The ground covered by these works, at present, extends from Twelfth to Fourteenth street, and eastward about a thousand feet, including two slips capable of accommodating eight or ten of the largest class of steamships. During the past week, there were no less than seven steamers, of the most extensive dimensions, at these works—the "Arctic," the "Franklin," "Cherokee," "Florida," "Alabama," "Columbia," and "Fanny." The whole machinery of the establishment is driven by a low-pressure steam engine of one hundred horse power, and of the most elegant construction, situated in the middle of the enclosure or yard, in a building constructed for that purpose.

"The whole establishment is divided into eighteen departments, at the head of each of which is a foreman to superintend

the mechanics and laborers under his particular direction. The following is a list of the number of men engaged in the whole concern, with their various employments, as furnished us by one of the Messrs. Stillmans:

Iron founders,	248	Painters,	3
Brass founders,	15	Masons,	6
Machinists,	359	Riggers,	31
Boilermakers,	242	Laborers,	38
Carpenters,	34	Cartmen,	6
Coppersmiths,	27	Clerks and Storekeepers,	11
Blacksmiths,	71	Watchmen,	6
Draughtsmen,	9	Patternmakers,	24
Metallic Life-boat builders,	17		
Instrument makers,	21	Total	1,170
Hose and Belt makers,	2		

"Besides these there are about twenty boat-builders in the establishment. The average wages for each man is about $1.50 per day, commencing at seven o'clock in the morning and ending at six in the evening. This makes a total of about $9,000 per week for wages alone; the yearly business transacted amounting to near a million of dollars. The business is increasing at a rapid rate, and it is calculated that before the end of another year, there will be an addition to the number of hands at present employed of at least two hundred, to meet the growing demand.

"Much has been done at these works to improve the machinery for making sugar. More than one hundred and twenty thousand dollars worth of this particular description of machinery was constructed here during the past year.

"This branch of business is not confined to the ordinary machinery of West India plantations, but extends to all the nice and complicated operations of that used in refining, even to the most minute instruments employed in testing the quality and condition of saccharine juices. The famous improvement in the manufacture of sugar in Louisiana, by which the value of the article has been nearly doubled, and which engrosses much attention among the planters, are the fruits of this enterprise. These improvements were made by Mr. A. Stillman, and consist

in the peculiar construction of the apparatus, by which one-half the quantity of fuel formerly consumed is saved. The machinery used in the refining process was formerly imported; it is now, however, thanks to the skill and enterprise of our mechanics, constructed entirely in this country. The extensive sugar refineries of Messrs. Havemeyer & Muller, of this city, and C. R. Dimond & Co., of Bristol, Rhode Island, may be quoted in proof of this statement.

"Some of these improvements have obtained a wide-spread popularity, and are in great request among the planters in Cuba and other West India Islands, where they have been introduced. In St. Croix, about ten years ago, there were more than one hundred and fifty plantations, and but three steam engines on the island; and these, from the difficulty of obtaining fuel, were put in operation only when light winds or calms threatened the loss of the crop by keeping the windmills in a state of inaction. The introduction of machinery, which requires but one-fourth of the fuel before used, has given the Novelty Works an enviable reputation, and conferred upon the island a permanent benefit.

"After this necessary digression we will return to our description. The iron foundry is a separate building, of two hundred and six feet long by eighty feet wide, with a wing upon one side, in which are four cupola furnaces, capable of melting at one heat sixty tons of iron, which, if required, may be deposited into one mould, making a single casting of that enormous weight. There is also another furnace, which is occasionally used for special purposes. The blast for the furnaces is made by Dempfel's fan, and is brought underground through a pipe, having a sectional area of about five square feet. Arranged upon the opposite side from the furnace are six drying ovens, each with a railway and two carriages, and each within the sweep of one or more of six cranes, some of which are capable of hoisting twenty tons.

All the different processes of moulding known to the artisan by the terms—loam, green, and dry sand moulding—are here carried on. The first process is generally performed without

patterns, in the following manner:—A wall is built of brick-work, which is coated over with a mixture of sand and clay, about the consistency of common mortar, and is put on somewhat in the manner that a mason plasters a house. This coating, when partially dried, is painted over with a mixture of finely ground charcoal, clay, and water, which prevents the adhesion of the loam to the iron. Some of these moulds consist of but two members or parts, while others have more. A bed-plate for the engine of a large steamer, has as many as eighty-seven members, all of which, in the process of moulding, are dissected from each other, dried, and again put together.

"This mould is about six weeks in preparation, employing in its various stages, from eight to forty men, and requiring about thirty-five tons of metal to fill it, which weight is exceeded by the plates and bars used in its construction.* The fluid metal is drawn from the furnaces as fast as melted, and deposited into two large receivers until a sufficient quantity is collected, when it is discharged into the mould. The process of cleaning off the mould, and hoisting out the casting, requires about a week. Green sand moulding is not so called from the color of the sand, but rather in contradistinction to the same material dried. This sand in its primitive state, is the common yellow loam, generally

* At the Novelty Works, the bed-plate of the Baltic was cast. It weighs 130,148 lbs., and is believed to be the heaviest casting ever made in the world. Within the past eighteen months, six heavy castings, including the above, have been made at this foundry. Previously the largest casting made there was that for the Arctic, a bed-plate, which weighed forty-five tons, and that for the Atlantic, which weighed thirty-seven tons.

In the summer of 1854, the cylinder of the steamboat Metropolis was cast here. This is the largest steam-engine cylinder in the world. It is one hundred and five inches in diameter, and fourteen feet in length, the stroke of the piston being twelve feet. Twenty-two persons sat down to lunch in this cylinder, with room enough, and to spare, and subsequently one hundred and sixteen men stood inside the flanges and fairly within the cylinder, on the platform which had been laid down for the table. A horse and chaise-wagon was also driven repeatedly through it, backwards and forwards. We should add, that the Novelty Works are no longer carried on by Messrs. Stillman, Allen & Co., but by a joint-stock company, under the title of "The Novelty Iron Works.

found near the surface of the earth. Large quantities of it are obtained from the suburbs of Brooklyn. When used in moulding it is damped to a considerable consistency, an impression is made on it from a pattern formed of wood, being in shape a fac-simile of the casting required. Dry sand moulding is the same process as that last described, with the addition of the coating of charcoal and clay, mentioned under loam moulding, and finished by drying in the oven.

"The amount of iron melted here in one month is about three hundred tons, all of which is of American manufacture. The whole department is under the skilful direction and management of N. M. Stratton, whose experience in this particular branch is well known.

"The casting of one of those large bed-plates for an ocean steamer, is one of the grandest spectacles imaginable. The liquid and fiery metal, after escaping from the furnace, rushes roaring and seething along the channels leading to the mould, throwing off, in its course, hundreds of bright and starry scintillations—

'It rises, roars, sends all outright—Oh, Vulcan, what a glow?
'Tis blinding white, 'tis blasting bright—the high sun shines not so!
The high sun sees not, on the earth, such fiery fearful show:
The roof-ribs swarth, the candent hearth, the ruddy, lurid row
Of smiths that stand, an ardent band, like men before the foe.'

"The casting of various portions of machinery was, in the early days of the art, attended with much danger, from the heated metal coming in contact with confined gas, which exploded, to the imminent danger of all in the vicinity. Now, however, such accidents are of very rare occurrence, owing to the skill and experience of modern mechanics.

"We have bestowed more attention on the foundry than we can upon any other department of the establishment, as we conceived it would be more interesting to the general class of our readers than dry details of the other branches, and must now, with a hasty description of the other portions, bring this already extended article to a hasty conclusion.

"In another portion of the concern is the machine shop,

where are sent the various pieces of machinery after being cast, to be subject to a refining and polishing process. Upon lathes of an appropriate size and strength are placed cylinders, piston-rods, and other parts of the engine, in a position in which they are exposed to the edge of cutters, which take off the rough portion of the surface, and plane it down to the required dimensions and smoothness. After this process they are again subjected to another, by which a polish is given them. In addition to these, there are several large planing machines and cutting mills, the former for smoothing the flat surface of iron, and the other for cutting round the uneven side of the interior of cylinders.

"Besides the foundry for iron, there is one also for brass, which is not materially different from the iron foundry, with the exception that the castings are necessarily smaller. The various parts of the engine composed of brass are made here. Passing to the blacksmiths' shop, we saw a large number of men at work, for whom, it seems, there is no lack of employment the whole year round. In this department there are about thirty forges in full blast, with a due complement of men to each. Large cranes for heavy pieces of iron are placed at regular intervals through the shop. An immense quantity of iron is worked up in this department daily, the wheels and other portions not cast in the foundry being made here. Messrs. Stillman, Allen & Co. make even the timepieces, thermometers, and similar instruments used on board steamships."

Cast iron is remarkably brittle, owing to the foreign substances with which it is more or less alloyed, and when fractured, we have no way of joining the parts other than by using rivets, and this method will not render a vessel tight again, or hide the defect. But the Chinese have long been celebrated for their singular skill in mending such vessels. The whole process is carried on in the open air, and all the workman requires is a little box sixteen inches long, six inches in width, and eighteen inches in depth, supplied with bellows, a few little crucibles, and a handful of charcoal. As soon as the little bits of cast iron with which the crucibles are charged are melted, the liquid metal is poured on a layer of partly charred husks of rice or paddy, previously

spread over a thick cloth, the object of which is to prevent the sudden cooling of the metal. Whilst in the liquid state, the metal is quickly conveyed with the right hand to the fractured part of the vessel and forced into it with a jerk. Then, with the left hand, a paper rubber is passed over the obtruding liquid on the inside of the vessel, making a strong, substantial, and neat operation.

Cast or wrought iron may be sawn, when at a red heat, with a common saw. To diminish the resistance, the saw should be fine and the iron must not be made too hot; for if the surface be too near a state of fusion the saw will be clogged and the process will not go on well. The saw should be moved very quickly, which will prevent its becoming much heated; it will also make its way better, and the cut will be more clean and exact. The iron should be so placed as to have a firm bearing every where, except where the saw is to pass, otherwise it is liable to break before the cutting is finished.

There are several ways of giving iron castings a coat of enamel or glaze, of which the following is probably as simple as any. It consists of three parts, by weight, of white lead (or one part of red lead and two parts of white lead), to two parts of borax and one part of calcined flints, which are to be fused, run into water, and ground in a glaze mill to the consistency of cream. The article coated is to be placed in a kiln in such a way that no flame or sulphur shall touch it, and heated till the glaze melts.

Another process is, to cleanse the article in an acid solution, and then cover it with a glutinous preparation, over which is laid a coat of glass, ground to a powder. The article is then introduced into a furnace of a peculiar construction, in which the glass is fused, and, the intermediate glutinous matter being evaporated, the glass fills the external pores of the metal, and becomes firmly united to it.

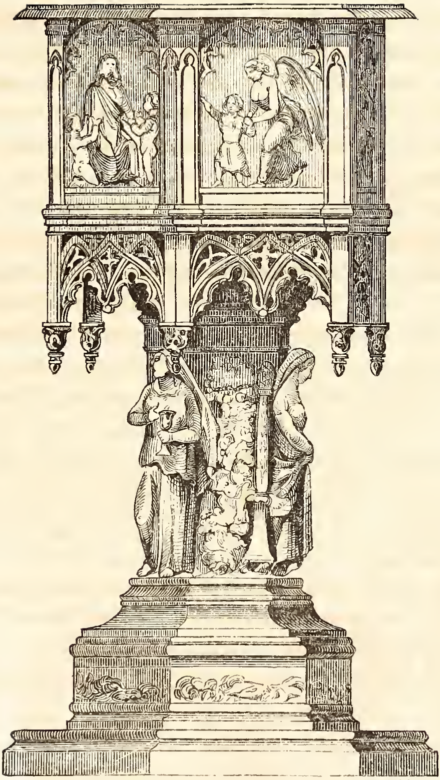
Iron may also be coated with zinc, and other metals, and the methods are very simple. For a coating of zinc, a quantity of that metal is melted in an open vessel, and on its surface is placed a layer of the chloride of zinc, or a mixture of chloride of zinc and chloride of potassium, and when in a state of fusion the metal to

be coated is placed in the bath, and allowed to remain there till a coating of sufficient thickness has been obtained; it is then withdrawn, and any parts of the surface imperfectly covered are sprinkled with sal-ammoniac, and the sheets of iron again immersed in the bath. Iron may also be coated with tin, silver, copper, or brass, the process being slightly varied in every case. Iron that has been coated with zinc, when worked over and rolled out into rods, has been found to indicate from five to ten per cent. higher strength than the best samples of wrought iron.

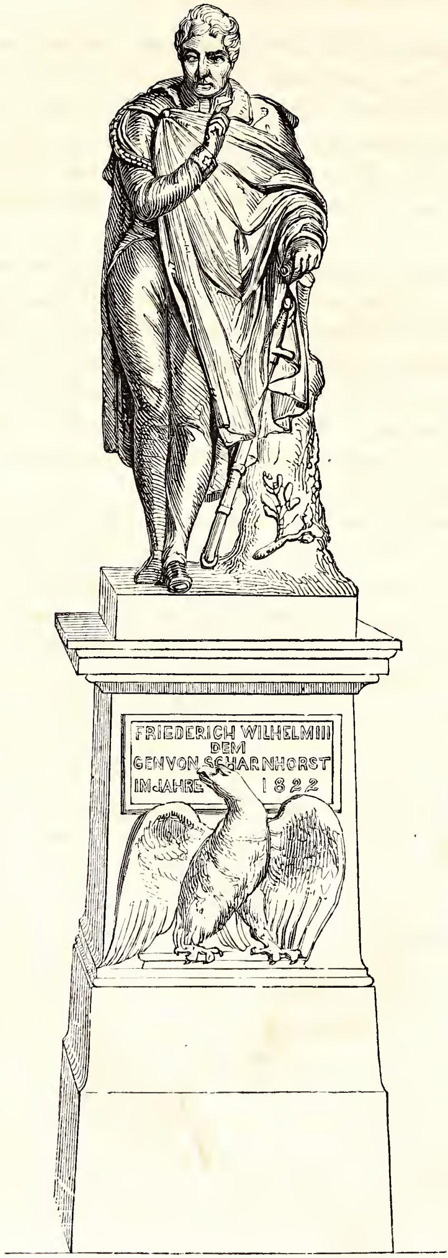
Berlin is now famous for its iron castings, which are unequalled. This is not owing to any superiority in the iron or coal used, for both of these are obtained from England, but to the superior quality of the sand employed for moulds, and probably to some peculiarity in the manner of fusing the metal. Whatever the secret may be, it is guarded well, and the workmen are constantly producing in iron, articles that are elsewhere wrought only in more costly metals.* The accompanying design, for a baptismal font, will illustrate this. Its form is Gothic, executed in the best style of the art, and, like other Berlin castings, it has a bronze surface to guard against rust, and it is lined with brass.

* A correspondent of the Scientific American thus writes to that Journal:—

"To produce such castings in iron [Berlin castings] it is necessary in the first place to have a perfect pattern, brass being generally preferred for this purpose; in the next place the pattern must be accurately moulded. In order to accomplish this, a fine close sand is required (perhaps Waterford sand would answer), which must be partially dried and sifted through a fine sieve. When the pattern has been moulded and withdrawn from the mould, the latter is dusted over with fine brick dust made from fresh burnt soft brick. The pattern is now dried, carefully returned to its place in the sand mould, and rapped home with a wooden mallet, and again withdrawn. If the mould has been sufficiently dusted, it will have a surface as fine as the pattern. The mould or flask is now put into the oven and dried. Before it is quite cold, it receives a coat of lampblack, by putting some oil in an open dish, and using a large wick so that it will burn with considerable smoke. The mould is now held over the smoking oil until it is sufficiently coated with lampblack. When this is accomplished, the flask is closed, clamped or screwed together, and is then ready for the molten metal. This is the way the fine Berlin castings are made. I have seen quite a number of these castings made in our country, by a Berlin workman, who was in my employ."



BAPTISMAL FONT IRON. p. 64



IRON STATUE TO GEN. VON SCHARNHOIST.

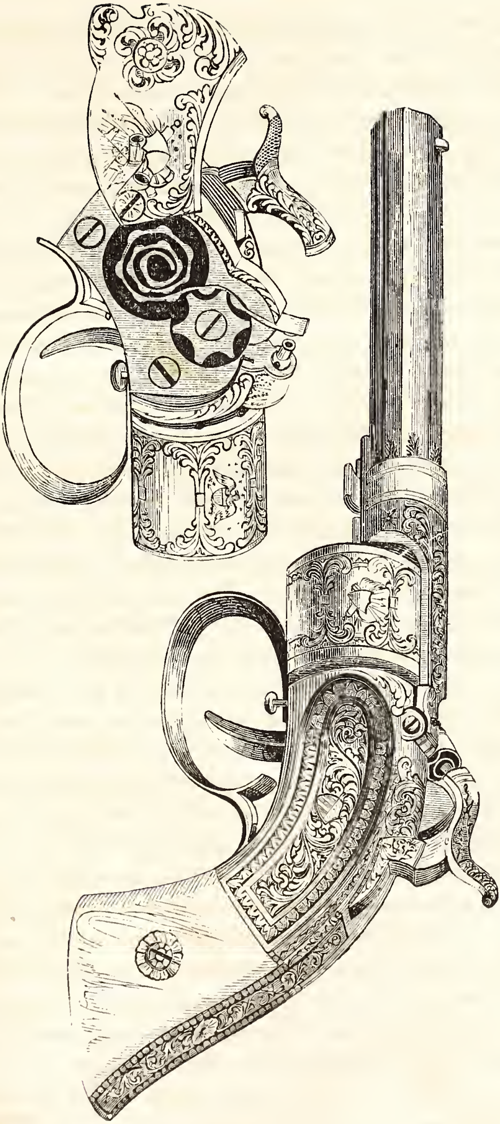
The Tazza, at page 25, is also from the same foundry, and is an admirable specimen of perforated work, conceived in good taste, and executed with clearness and decision. At page 38 there is a statuette of Marshal Blucher, and we here introduce one erected to General Von Scharnhorst, by King Frederick William III. They are both of iron, coated with bronze, and are from the Berlin foundry.

A writer in one of the London papers asserts that cast iron is the best known material for cannon. One of the cast iron guns taken at the capture of Bomarsund underwent an experimental trial, and the Russian metal, contrary to all expectations, withstood the experiment unharmed. The grand object is to have the iron properly made. Iron smelted with common coal is always inferior to that smelted with charcoal, and herein consists the secret of the superiority of the Russian cast guns.

Cannon are cast from wooden models, which have been exactly and smoothly turned in a lathe, so that they may leave the sand with facility during the process of moulding, and as the model does not admit of being drawn from the sand like a smooth cylinder, it is moulded in a box or flask, after the manner already described. The metal must be of the very best, and after it is cast it must be bored. To effect this, it is first fixed in a stout iron frame, between two centre points and "engine turned" all over the outside, with sharp steel tools properly fashioned, and then it is placed horizontally in two cast iron supports, each containing a hollow brass gully fitted to the gun at the breech and at the neck, and over which a collar is screwed down, that the piece may revolve steadily. A sharp steel drill is then brought in contact with the muzzle of the gun, which is made to revolve slowly, and when the gun is bored to the proper depth by this process, the drill is removed, and another instrument introduced in its place. This consists of a shaft of iron shot at the extremity with four or five square bits of steel, attached by longitudinal grooves to the rod. This widens the bore about the eighth of an inch, at the same time it smooths and perfects the calibre to the exact dimensions required. After it is perfected, it is examined at the arsenal, by introducing a spring instrument, called a *searcher*, to detect any flaws or imperfections that may still exist in the iron.

But the old way of casting guns solid, and then boring them, has received a blow, from the recent discovery of the superiority of guns cast hollow, that it will not recover from. The new process is, to form a core on a tube of iron, through which a current of water is made to flow; and where a gun, cast on the old principle, burst on the seventy-eighth discharge, one on the new, and of the same calibre, stood fifteen hundred rounds without bursting. This superiority is attributed to the mode of cooling. The solid guns contract entirely from the outside, and it is supposed that a strain is exerted upon the arrangement of the particles of the metal in the same direction as the strain of the discharge.

Cannon appear to have been used in the second half of the fourteenth century: they did fearful execution in battle, but the difficulty of managing these engines of war, and the small number an army was then able to transport, prevented their introduction from diminishing the importance of chivalry, which was never more brilliant than towards the close of the sixteenth century, under Maximilian in Germany, and under Charles VIII., Louis XII., and Francis I. in France. The idea was then suggested of multiplying the ravages of cannon by distributing to the infantry more portable and more destructive fire-arms. These at first were little cannons which were carried by two soldiers on the march, and placed upon rests or props at the time of battle. Soon the size of these arms was again reduced, and they were fixed in a stock, to allow of the soldiers' taking aim more readily, the cheek was applied to the butt, which was curved and held in the left hand, the end of the piece was supported on the *forquine*, a staff with a kind of iron fork driven into the ground. The powder in the fire-pan was ignited with the right hand by means of a match. This weapon received the name of arquebuss. One hand was required for its support and this made it difficult to adjust, and moreover the rest was inconvenient to carry; the next improvement was to place the match in a long curved bar, called a serpentine, which conveyed the fire to the pan by the pressure of the finger upon a trigger placed along the stock. The match presented numerous inconveniences: it was next exchanged for something of less imperfect construction. Under the fire-pan was



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fixed a furrowed wheel of steel, which communicated with the bottom of the pan by means of a slide; and against this wheel was placed a flint held between two strong clams of iron, like the cock of a gun. On removing a catch, the wheel, which was turned by a spring, attached to it by a chain, revolved so rapidly against the flint as to elicit sparks, which lighted the powder in the pan. These arms were denominated wheel arquebusses. Not unfrequently both match and wheel were used in the construction of the same piece, in order that the one might take effect in case of the other failing.

From the time that fire-arms were made portable, they became fitting subjects for the decoration of art. The barrels of the arquebusses and pistols were enriched, like the armor, with fine chasings and ornaments, damascened in gold and silver. The stock was ornamented with fine incrustations: for which were used ivory dyed in various shades, and woods of different colors; sometimes it was overlaid with slabs of ivory, upon which were engraved figures, subjects, and ornaments of great delicacy. The plate of the lock and the hammer were also richly decorated, having chased on them ornaments, arabesques, figures in relief, and often even charming little figures in full relief. The perfection which the arts of design had by that time attained in Italy, France, and Germany, admitted often of giving a great artistic value to the ornamentation of fire-arms.

The improvement of the present century in fire-arms is of the most marked character, and they deal out death and destruction whenever brought into play, whether in the form of the ponderous cannon or that of the repeating rifle and pistol. These last are now deemed indispensable alike to the soldier and the hunter, and the name of Colt is now known in all parts of the world, in connection with his pistols, which are wholly unequalled.

The pistol here introduced presents another variety of the repeating arms, for which America has become famous. It is manufactured by the Massachusetts Arms Company, at Chicopee Falls, and is very beautifully finished. Its chief peculiarity consists in the Maynard Primer, the arrangement of which will be seen in the engraving.

A strip, containing fifty charges, is coiled up and placed in a magazine in the lock, and is fed out by the action of the lock, one charge at a time, as the hammer is raised. When the hammer descends, it cuts off and fires the charge fed out upon the vent or cone, thus igniting the cartridge within the barrel.

The detonation of the Maynard Primer is in the form of little lozenges, each about one-sixth of an inch wide, and one-thirtieth of an inch thick. These lozenges are enclosed between two narrow strips of strong paper cemented together, and rendered water-proof and incombustible. The single strip thus formed, is a little less than one-fourth of an inch wide, is very stiff and firm, and contains four of these lozenges (each of which is a charge) in every inch of its length; the charges forming projections, of their own shape, on one side, having considerable and equal spaces between them; the other side of the strip being one flat and even surface.

CHAPTER IV.

WROUGHT IRON AND STEEL.

IN order to transform cast iron into wrought, it is necessary to separate from it the carbon and silicium with which it is combined. To effect this object, the metal is exposed for a considerable period to the action of oxidizing influences, by which the carbon is converted into carbonic acid, which escapes in the gaseous form, whilst the resulting silica unites with oxide of iron, giving rise to the formation of vitreous slags. Cast iron also frequently contains small portions of sulphur and phosphorus, which require to be carefully removed during the process of refining, as their presence in the wrought iron produced would materially affect its properties, and, if occurring in large quantities, render it entirely useless. The separation of these substances from cast iron is attended with very great difficulty, and their occurrence in the rough metal is, therefore, avoided as far as is possible.

When cast iron is strongly heated in contact with air, its surface soon becomes covered with a layer of oxide. By degrees this oxide again reacts on the interior portion of the mass, the carbon which it contains reduces the oxide first formed, metallic iron is produced and carbonic oxide gas is evolved.

When the metal is judged to be sufficiently refined, the workman collects it together in the form of large balls, and exposes them successively to the action of a heavy hammer, by which the vitreous slag is expelled, and the spongy metal compressed into

a compact form. The operation by which the last portions of carbon are extracted from the metal, is called *puddling*, and the puddled iron, after being properly compressed by the heavy hammer, is again heated and then passed through a series of rollers, by which it is formed into bars of greater or less length and diameter.

Some of these hammers are of immense size, and the blow can be graduated with a nicety that becomes wonderful when we consider their great weight. The largest trip hammer in the United States is that at the Cold Spring, West Point, Foundry. It weighs eleven tons, and has a drop of from fifteen to eighteen inches. The hammer is elevated by means of a toothed wheel, and it then falls with a crushing weight. The blow from a steam hammer can be graduated—a thing not to be done with a trip hammer. The most powerful steam hammer in the country is that at the Reading Steam Forge, which weighs seven tons, and has a fall of seven feet. It is this great fall that makes it so effective, and while it is so arranged that the full force of the blow can be brought to bear on a piece of iron to be forged, it can also be graduated to crush a walnut. The Franklin Forge, New York City, has a hammer weighing seven and a half tons, with a drop of six feet. This is one of the largest in the United States, and has been used successfully to forge wrought iron shafts twenty-eight inches in diameter or seven feet in circumference.

Puddled iron which has been rolled into bars, immediately on its removal from under the hammer is always of very inferior quality, being extremely hard and brittle, besides being subject to numerous flaws and imperfections not observed in ordinary bar iron. This may be employed for some purposes, but iron required for ordinary use should be possessed of tolerable tenacity. Its quality is improved by cutting the rough bars into short lengths, and afterwards welding them together in bundles, and again passing them through a set of rollers.

Sheet iron is made either by hammering the heated metal to the proper thickness by the same methods that in some localities are still employed for the purpose of drawing it into bars, or it is made to acquire the proper form and thickness by being passed, when

strongly heated, between smooth rollers with polished faces, arranged in the same manner as those intended for reducing it into bars.

The metal employed for making sheet iron ought to be very soft and tough; and when thin sheets are required, such as those of which tin-plate is manufactured, the best charcoal-prepared iron only can be used.

To give the metal the form of sheets, it is repeatedly passed through sets of rollers, and when it has been rolled into very thin sheets, such as those employed in the manufacture of tin-plate, the smoothing of the surface is effected by a distinct and separate operation. For this purpose, the reduced metal, after being heated to redness, in order to restore its softness, is laid in successive layers on a smoothly polished surface of cast iron, where it is strongly compressed by the descent of another surface, acted on by hydraulic pressure.

A singular illustration of the tenacity and ductility of iron has been produced at an iron establishment in Birmingham, England. It is in the form of a book, the leaves of which are of iron, rolled so fine that they are not thicker than a piece of paper. The book is neatly bound in red morocco, and contains forty-four of these iron leaves—the whole being only the fifteenth of an inch thick. This curious book was rolled in the ordinary sheet-iron rolls.

At equal strengths wire rope is lighter by one-third than a hemp one, and by two-thirds than a chain. It was in 1828, that wire rope was first put into use, and by the inventor of the metallic shutters, who found in a confined space, when cat-gut was destroyed by the rats, nothing but a wire rope would serve his purpose. The substitute answered well, and after years of experiments, a patent was taken out in 1835 in England, and another in 1839, and now wire rope is applied to a variety of uses, and its importance is yearly becoming better understood.

The manufacture of needles is carried on in this country, though only of late years; England, and the celebrated house of Hemmings & Son, having supplied us almost exclusively with this article.

The wire for needles is expressly drawn for that purpose. It is cut into lengths according to the size of the needles to be made, then straightened and pointed on a stone which revolves with great velocity; then they are stamped, to mark the place for the eye, and the hole is punched by means of the proper machinery. The burr made by stamping the eye is filed smooth, after which the hardening and tempering is performed, and then they are again straightened so as to make the shape perfect. By means of machinery the needles are scoured and brightened, and the closing processes are, the assorting, by placing the heads and points their respective ways, the eyes blued, or the temper at that point taken out, that they may not cut, and the drilling, countersinking, and burnishing the eyes.

Gold-eyed needles are produced by dipping the head of the needle into the spirits of ether containing a little solution of gold, and which immediately attaches itself to the steel, when dipped in the menstrum. Needles are sometimes treated with this ethereal solution of gold all over, in order to give them a beautiful yellow color, and at the same time to prevent them from rusting. There is also a variety of needles called silver-eyed; but not a particle of silver, or any thing like it, is used, the peculiar white polish of the eye being given by means of its application to a little cylinder stuck full of steel pegs. The drilled-eyed needles are esteemed highly, but they are no more drilled than the silver-eyed owe any portion of their finish to that metal The eye is countersunk, and smoothed on both sides by a drill after punching: this not only makes them look well, but renders them, when carefully made, little, if at all liable to cut the thread.

The process of making axes has been greatly simplified within a few years. The iron is rolled into bars the proper width and thickness of the axe, and eight or ten feet long; it is heated and cut off by a large pair of shears propelled by water power; another workman picks up each piece and places it between a die and punch, and the punch comes down and forces a hole for the handle by punching out a piece. An iron mandrel is now inserted in the hole, and it is immediately put under another press

which forms one side of the axe, and then goes to another die, which forms the other side, when it is placed in an upright position, and a chisel comes down and splits the "bit" of the axe, ready for the steel, and then it is thrown one side. All this is done at one heat and in less time than it takes to write out the *modus operandi.* The blade of the axe is then put in and welded, and passed along to the forger, who tempers it and casts it upon the ground to cool. As soon as it is cool it is taken up, planed down to an edge by a planing machine, finished up with emery wheels, painted, labelled, stamped, and put up for market.

Anvils for blacksmiths' work are formed of wrought iron, generally scraps, with a projecting base and buttress at the corners, in order that it may stand firmly upon the surface of a stock, which is always of wood. The anvils upon which steel articles are to be forged are generally fashioned at the bottom nearly in the form of cubes, for insertion, by means of wedges, either in stone or wooden stocks. In hardening anvils, as well as large hammers, the mass is not suddenly immersed in water, as is the method with articles of steel generally; such a course with so large a body would be unsuccessful, as the ebullition thereby caused would be so great that the steel would be prevented from coming into that immediate contact with the water which is necessary to produce hardness. Instead, therefore, of instantly plunging the anvil, it is suspended by chains and lowered by means of a windlass into a tank, and a stream of water is then suffered to fall from above upon the steel face, until the latter is sufficiently cooled, and, as it becomes tempered by the heat remaining in the body, it is dropped into the water below, and quenched till it becomes quite cold.

For all the delicate works in wrought iron that have a value for the artistic skill displayed in their form and adaptation to our wants, the small hammer in the hands of the workman, and the ringing anvil, must still hold the position they have maintained for centuries. Metal working in the Mediæval ages was an art, and one of the chief attractions of Antwerp is the iron well curb, wrought by Quintin Matsys; and the inhabitants of Nuremberg instinctively point the traveller to the works of Peter Vischer and

his five sons, as well as to the stone carvings, and painting and engraving of his cotemporaries, Adam Krafft and Albert Durer. In Nuremberg the art of wire drawing was invented, as was also the air gun and the first watch, and there the first observatory was erected by the astronomer Walther. The most famous artist of the seventeenth century was Gottfried Leigeber, born in Silesia; he worked at Nuremberg, and died at Berlin in 1683. He was at first a common armorer, and brought himself into notice by his ingenious compositions, and particularly by his very delicate finish. He made a large number of bas-reliefs in iron, but the most esteemed of this artist's works in Germany are equestrian statues of rather large size, cut in blocks of iron.

The hand of the iron worker is conspicuous on almost every house in Nuremberg, in the form of locks, hinges, and knockers, all exquisitely wrought in metals, and chiefly in iron. In every thing that appertained to the art they excelled, and as the old Venetians prided themselves on giving a new form to every article of glass that came from their hands, so it is difficult to find at Nuremberg two buildings with adornments of iron after the same pattern. The trade of the city was expansive, and articles of varied manufactures there produced readily found a market in other parts of Europe, as well as in the East, where they were exchanged for the rich goods of India. In the ornamental work of that period still preserved to us, we find great purity in the delicate tracery they loved to employ; and the more elaborate works, in which the metals are alloyed, the figures are modelled with a fine appreciation of the beautiful.

If the purest iron be surrounded by charcoal powder, and the whole covered with sand, and exposed to a long continued red heat—eight or ten days for a charge of ten or twelve tons—it unites with one one-hundred and fiftieth of its weight of carbon, and acquires new properties, being converted into steel. The experiment has often been tried, of closing up a small diamond in a cavity of soft iron, and submitting it to the action of the fire, when it is found that the diamond disappears, and the inner surface of the iron is converted into steel. When ignited and suddenly cooled, it is rendered so hard and brittle as to be wholly unfit for

useful purposes. To fit it for use it requires to be tempered, which consists in heating it to a certain point, and this is indicated by the various colors the metal assumes on its surface when it is suddenly cooled; but in this process there is much art, for the change may be so great as to cause it to crack or exhibit flaws. The rule that governs the process for preparing steel plates for the Bank of England is, to heat the metal in a fire not above the redness of sealing-wax. In taking it out it is hardened by plunging it—not in water, but in olive oil, or rather naphtha, previously heated to 200° Fahr. It is kept immersed only till the ebullition ceases, when it is immediately transferred to cold spring water, and kept there till quite cool. Steel tools are frequently tempered, after hardening, by covering their surface with a thin coat of tallow, and heating them in a flame of a candle till the tallow diffuses a faint smoke, and then thrusting them into cold tallow.

The more steel is rolled, and especially the greater degree of pressure there is laid upon it as it becomes cooled, in the same ratio does it approximate in closeness of texture and practical value to that which has been drawn out under the hammer; the latter, indeed, being often worked with considerable less of uniformity, both in the heating, beating, and the extending, than the former. In order to get the bars of the exact size required, the workman has a gauge which he applies to measure the width and thickness of bars, and the strength of plates; and such is the nicety of perception acquired by an eye daily conversant with such matters, that he rarely fails to hit the required size with the utmost precision.

All steel, whether cast or shear, which is to be used for the best articles, should be tilted to the strength required, by working it under a large hammer, put in motion by machinery, and which gives about three hundred strokes per minute. During the operation of hammering, so important in closing the pores of the steel, and thus rendering it exquisitely dense and compact, the tilter sits on a seat reaching nearly to the ground, and suspended from the roof of the building. By this contrivance, and with the aid of his feet, he advances to, or recedes from, the anvil,

upon which he manages the bar under the hammer with singular dexterity.

In firing, some of the bars are blistered, as it is termed, which results from the escape of gas or vapor incorporated with them. If the blistered bars are broken and welded together, we have shear steel. The bars that come out of the firing in a perfect state are known as cementation steel; and these, if broken up and fused in a crucible and protected from the action of the air, produce cast steel, which is more uniform than the other varieties.

One of the new methods of manufacturing cast steel, as described by the Scientific American, consists in the introduction into crucibles, along with the pieces of wrought or malleable iron, of certain chemicals in which cyanogen is contained. The usual furnaces and melting pots suitable for melting blister steel may be employed. The malleable iron—which may be of any description, such as bar, scrap, bloom, &c.—is prepared by cutting or breaking it up into small pieces. With a charge of fifty pounds of iron, ten ounces of charcoal, six ounces of common table salt, half an ounce of brick dust or oxide of manganese, one ounce of sal-ammonia, and half an ounce of ferrocyanide of potassium, are introduced into a crucible. The pot is then to be covered and placed in a furnace, and the contents thoroughly melted, the heat being maintained for the space of three hours or thereabouts. The mass is then to be poured off into iron moulds in the ordinary way of pouring cast steel, and with the usual care for producing a solid ingot. This may then be rolled into sheets, or hammered and tilted into bars, after the common method.

Mr. Bessemer, in his new process for manufacturing iron, already described, also claims that he can, by arresting the process at a certain point, obtain cast steel. He says that, at the state of the process immediately following the boil, the whole mass is converted into the ordinary quality of cast steel. As the carbon gradually burns off, the iron passes through the various conditions of hard steel, soft steel, steely iron and soft iron. At a certain stage, therefore, a metal may be obtained which he calls semi-steel, and which he affirms to be stronger, more elastic, harder and more durable than common wrought iron.

Steel may be alloyed in various ways, and not only silver, but platinum, rhodium, gold, nickel, copper, and even tin, have an affinity for steel sufficiently strong to make them combine with it. The finest of these alloys is that of steel with rhodium; but that which is most used, and which is next to it, is steel with silver, and experience has proved that one of silver to five hundred of steel is the best proportion. If steel and silver be kept in fusion together for a length of time, an alloy is obtained, which appears to be very perfect while the metals are in a fluid state; but on solidifying and cooling, globules of pure silver are expressed from the mass, and appear on the surface. If an alloy of this kind be forged into a bar and then dissected by the action of diluted sulphuric acid, the silver appears, not in combination with the steel, but in threads throughout the mass, so that the whole has the appearance of a bundle of fibres of silver and steel, as if they had been united by welding. The appearance of these silver fibres is very beautiful; they are sometimes one-eighth of an inch in length, and suggest the idea of giving mechanical toughness to steel, where a very perfect edge may not be required.

At other times, when silver and steel have been very long in a state of fusion, the sides of the crucible, and frequently the top also, are covered with a fine and beautiful dew of minute globules of silver.

In making steel alloys the proportion of one to one hundred and sixty, uniformly gives silver and steel in fibres, and the silver in globules appears when forged. When the proportion is one to three hundred the fibres diminish, but still are present; and they are detected even where the proportions of one to four hundred are used. But when the proportion is one to five hundred, the alloy forges remarkably well, though very hard, and when it is tested every part of the bar gives silver. Various cutting tools, particularly razors, are made from this alloy, for which use it is admirably adapted.

Iron is alloyed by an admixture of tin, lead, and arsenic, producing a metal of which bells, rich in sound, have been made at a cost considerably less than that of bell-metal.

Steel may be distinguished from pure iron by applying a drop

of any weak acid to the surface, when the charcoal it contains will be exhibited by a black stain. Cast steel works much harder under the hammer than shear steel, and will not in the usual state bear much more than a cherry red heat without becoming brittle; but it may be firmly welded to iron through the intervention of a thin film of vitreous boracic acid, at a moderate degree of ignition. Iron may be faced with cast steel by pouring the liquid metal from a crucible into a mould containing a bar of iron polished on one side, and the adhesion is so perfect as to admit of the two metals being rolled out together. In this way mechanics' cutting tools are made at a moderate cost, and of excellent quality.

Case hardening consists in converting the surface of iron into steel, while the body retains the toughness of iron. The article is first neatly finished, and then placed in an iron box with vegetable or animal charcoal, in powder, and cemented for a time. Immersion of the heated piece in water hardens the surface, which is afterwards polished, and then the prussiate of potash is sprinkled upon the part intended to be hardened. The prussiate being decomposed and apparently dissipated, the iron is to be quenched in cold water, when, if the process has been well managed, the surface of the metal will have become so hard as to resist the file.

The Swiss harden the blades of knives, razors, and other similar objects made of cast steel, by dipping them at a dark cherry red heat in a bath of powdered yellow rosin, fish oil, and molten tallow; they are then allowed to cool perfectly, and, without wiping them, they are re-heated to a low red heat and immersed in water, in the usual way of tempering such articles.

Burnt steel may be regenerated by heating it to a red heat, and putting it when in this state into boiling water. Repeated experiments at the Royal Mint at Berlin have proved perfectly successful.

A curious experiment for cutting steel was first tried in this country, and its success has been very generally acknowledged. The operation is performed by placing a circular plate of soft sheet iron on an axis in a lathe, and when a very rapid rotary motion is given to it, the steel brought into contact with the edge is readily cut in two. Hardened or soft steel and wrought

iron may be cut in this way, but it is very singular that on cast iron it will not produce the slightest effect.

The art of damascening consists in expressing a design by means of wires of gold or silver imbedded in a less brilliant metal. Sometimes also we meet with damascene work executed upon gold with silver threads or upon silver with gold. The ancients practised this art with success. They attributed its invention to Glaucus of Chios. The celebrated Isiac table (which derives its name from the goddess Isis, who is depicted upon it) refound at a locksmith's, after the sack of Rome in 1527, was enriched with a fine damascene, which shows the Egyptians to have excelled in the art. It was also practised in the middle ages; but the scarcity of works of that period serves to show that the nations of the West were not then acquainted with the process of enriching their works of iron or bronze with this kind of decorations. The people of the Levant had, on the other hand, acquired great celebrity for this kind of workmanship, and from its being most successfully practised by the people of Damascus, the art derived its name from that city.

With the opening of the sixteenth century, the services of the engraver, damascener, and the goldsmith, were all called into requisition to enrich with decorations the armor of princes and knights, for which the first artists of Italy often furnished designs. The helmet, and many other parts of the armor, was covered with figures, arabesques, and ornaments in hammer work, engraved, chased or damascened with gold and silver, and the shields were often covered with very complicated subjects in bas-relief. The horse was as richly caparisoned as the rider. The chamfron (a piece of iron which covered the head of the animal, from the nape of the neck to the nostrils), was specially chosen for the richest decorations. At length iron was considered too base a metal for the armor of the nobility, and was often concealed by a rich gilding, and Sir Walter Raleigh went even further, and appeared at the court of Queen Elizabeth in a suit of armor composed of massive silver.

The imagination and talents of the artists were exercised also on the swords, alike for use and ornament. Every point of the hilt was enriched with ornaments and arabesques in relief, and

even with little figures in full or high relief, sculptured in the iron with exquisite delicacy; fine engravings, damascening, and enamels were equally employed in their ornamentation, while the guard assumed an elegant and complicated form.

The true Damascus blades possess great keenness of edge, wonderful flexibility, a peculiar flecked grain, and a remarkable musky odor when bent or rubbed.

The general impression is, that the old method of preparing Damascus steel was, to weld together wires of iron and steel and give them twists in different directions, during the process of welding. This is the plan now adopted to give the usual ornament to twisted rifle barrels. Bars of steel and iron, placed in regular alternations, are welded into one bar. This bar, or two of them placed together, undergoes a spiral twist, and then a process of welding. Upon polishing the gun barrel, very intricate and often elegant patterns will be apparent.

One hundred parts of very gray cast iron, and an equal quantity of like filings previously oxidized, produce, by their fusion together, a beautiful damascene steel, fit for forging into blades.

In damascening, the metal is either cut deep in lines that represent the design, and the gold and silver wire forced in; or, after it is heated till it becomes of a blue or violet color, it is hatched over and across with a suitable instrument, after which the ornamental design is traced on the steel with a fine brass point or bodkin, and when the metal is chased, fine gold wire is sunk into it with a tool made for the purpose.

Of works of this description Benvenuto Cellini speaks in his charming Autobiography. It was a peculiarity of his mind that he never saw a work of art, executed in a style new to him, that he did not try, first to imitate and then to improve upon it; and he thus describes his success with the damascened blades that fell into his hands:

"There fell into my hands some Turkish daggers; the handles of which were of iron as well as the blade, and even the scabbard was of that metal; on these were engraved several fine foliages in the Turkish taste, most beautifully filled up with gold. I found I had a strong inclination to cultivate this branch likewise,

which was so different from the rest; and finding that I had great success in it, I produced several pieces in this way. My performances indeed were much finer and more durable than the Turkish, for several reasons; one was, that I made a much deeper incision in the steel than is generally practised in Turkish works; the other was, that these foliages are nothing else but cichony leaves, with some few flowers of echites; if these have some grace they are not lasting like those of our foliage. In Italy there is a variety of tastes, and we cut foliage in many different forms; the Lombards make the most beautiful wreaths, representing ivy leaves and others of the same sort, with agreeable twinings, highly pleasing to the eye. The Romans and Tuscans have a much better notion in this respect, for they represent acanthus leaves with all their festoons of flowers, winding in a variety of forms, and amongst these leaves they insert birds and animals of several sorts, with great ingenuity and elegance in the arrangement. They in part have likewise recourse to wild flowers, such as those called lions' mouths, accompanied by other fine inventions of the imagination, which are termed grotesque by the ignorant. These foliages have received that name from the moderns, because they are found in certain caverns in Rome, which in ancient days were chambers, baths, studios, halls, and other places of the like nature. The curious happened to discover them in these subterraneous caverns, whose low situation is owing to the raising of the surface of the ground in a series of ages; and as these caverns in Rome are commonly called grottos, they from thence acquired the name of grotesque. But this is not their proper name, for as the ancients delighted in the composition of chimerical creatures, and to the mixed breed of animals supposed to spring from the promiscuous conjunction of goats, cows, and mares, gave the appellation of monsters; in like manner produced by their foliages monsters of this sort, and that is the proper name for them, not grotesques. In such a taste I made foliages, filled up in the manner above mentioned, which were far more elegant and pleasing to the eye than the Turkish works."

Ornaments are not uncommonly put upon steel by the chemical action of solutions of various metals, most of them being com-

binations of acids. The steel is first covered with some etching ground, through which the design is cut to the surface, and the metallic solution being poured upon it, the metal or its oxide is precipitated through the lines and a superficial chemical combination is thus effected.

Steel may be gilded by the employment of the ethereal solution of gold, and upon dipping the metal into the solution an electro-chemical action appears to take place, the result of which is, a film of gold is deposited upon the metal. In this way gold-eyed needles receive a small coating of the precious metal, and many steel ornaments are fancifully decorated.

A very brilliant display of colors may be produced upon steel by depositing upon it films of lead by the agency of a voltaic battery. The piece of steel to be ornamented is connected with one pole of the battery, and upon it is placed a cardboard perforated pattern of any suitable design. This is kept in close contact with the steel, and it is placed in a solution of the sugar of lead. A wire from the opposite pole of the battery is now brought down upon the steel, piercing exactly through the centre of the perforated card. A beautiful series of colors, in thin films, and enlarging gradually, cover every part of the steel plate except those on which the paper of the pattern is pressed.

A new process for ornamenting the surface of steel—and it may be applied to other metals—consists chiefly of the combined process of transferring impressions from engraved or painted surfaces to the metal, and electro-plating or electro-gilding them after biting out the metal, so as to leave the design either sunk or in relief. To effect this the surface is well cleaned by rubbing it with wash-leather and powdered lime, when the impression of an engraved plate or stone, taken on tissue paper, is laid on its surface and rubbed with flannel, after which the paper is washed off. A solution of gum guiacum in spirits of wine is then applied to the surface of the metal, by means of a camel-hair pencil, after which the coating of gum, which is over the impression, is readily removed by the use of a piece of cotton wool dipped in spirits of wine, the gum not fixing on the impression. The impression is

then bitten out with acids in the usual way adopted by etchers and engravers on metals.

In order to obtain engravings in relief the process must be reversed, the engraved part being protected by means of resin or asphaltum dusted on it, the plate being warmed to insure the adherence of the parts required, after which the other parts of the surface are bitten out with acids. The metal plate, in either case, is next washed with a hot solution of soda or potash, to remove all traces of acid, and scratched with a wire brush, after which it is placed in the electro-plating or electro-gilding apparatus.

Niello is the name of a process frequently resorted to in the fifteenth century, as a means of ornamenting gold and silver, though it was practised at a much earlier period. It is a composition of silver, lead, copper, sulphur, and borax, which, when fused, produces a black color, and it was used in the following manner. The design was hatched (cut in lines and crossed) on the gold or silver plate, with a steel point, and finished with an engraver's burin; then the composition above described was run in while hot, and the superfluous parts were rubbed off, leaving the engraved design much resembling a print.

A woman having accidentally gone into the studio of one Finiguerra, a Florentine engraver in metals, laid down a wet cloth upon a plate engraved in niello, and was not a little surprised when she took it up again to find the whole of the engraving stamped upon it. This incident made a deep impression on the mind of Finiguerra, who tried various experiments and at last produced a perfect etching on paper, with an ink made of soot and oil, and a proof print of one of these works is now in the Louvre. The plate, engraved by him in 1452, of the first engraving ever printed, is in the cabinet of the Florentine Gallery. No other man was ever known to engrave so many figures in so small a space, with such perfect correctness of drawing. This process may be said to be the origin of engraving on copper, and subsequently, on steel.

If steel be heated and then cooled suddenly, as we have already remarked, it becomes hard and brittle; but if cooled

slowly it is rendered soft so that it may easily be cut with the small tools employed by the engraver, who takes advantage of this quality to prepare plates for his use. Sheets of steel, of the required size and thickness, are placed in a box upon a bed of iron filings and pounded oyster shells; then another layer of the same materials is placed upon the plate, and so on, alternately, till the box is quite full. The case, thus charged, is exposed to the greatest heat it will bear without melting, for several hours. The whole is then allowed to cool very gradually, and usually the result is a uniform softening of the steel, which is now suitable for the use of the engraver. The outline of the subject to be represented, with the form and place of the lines which are to mark the shades of the engraving, are lightly traced on the polished surface of the plate with a point. Then a tool, called a graver, corresponding in size and form to the line required to be traced, is pushed forward, like a gouge, to cut the plate, by which means little pieces of the metal are scooped out. The strokes or lines, which are gradually increased in number, produce, according to their thickness and position, tints more or less varied; and the most perfect engraving is, in fact, but a reproduction of the lines on the plate.

Machinery has been brought to the aid of the engraver, particularly for ruling parallel lines, and a great invention, to assist the engraver of bank-note plates, is that known as the geometrical lathe, by the aid of which the workman can not only cut circles and ovals rapidly, but also, by certain combinations of lines, a great variety of figures may be produced. The inventor is Cyrus Durand, an engraver and a man of ingenuity we may well be proud of. To him we are indebted for several valuable inventions besides the one above named, among them an engine lathe for ornamenting watch and pencil cases.

But to return to our subject. There are various ways of engraving, such as etching, stippling, mezzotinto, &c., but it is not necessary to refer to these different modes here. Wood engraving is the opposite of that already described, for the lines in a steel or copper plate are scooped out, while in wood engraving they are left standing: that is, the surplus wood is cut away,

leaving only the lines that represent the design, and in this way the embellishments of this book were first produced. After they were engraved, electrotype copies were taken, to print from, by a process that will be described under its appropriate head. The advantage that wood possesses over copper or steel is, the subject can be printed at the same time with the text, whereas an impression can only be obtained from a plate by a slow and tedious process. The plate, after it is engraved, has to be hardened again, in the ordinary manner for hardening steel. Then the printer heats it uniformly up to a certain point, to make it take the ink into the finer lines more readily, and after the ink has been applied with a dauber the superfluous color is wiped off. This is a very delicate part of the operation, and after it is properly performed, the plate is placed on the press, covered with a damp sheet of paper to receive the impression, and over all four or five pieces of blanket are laid. The whole is then submitted to the pressure of the cylinder, and when it comes out the paper is found to bear the complete impression of the engraved plate.

Some of the earliest specimens of engraving on steel, for the purpose of printing, were produced by Albert Durer. There are four plates etched by this master, impressions of which exist in the British Museum, which, in all the books treating on this subject, are recorded as having been executed in steel; of these one has the date of 1510. And, we may also remark, that notwithstanding its hardness, iron has not escaped the chisel of the sculptor. It was principally in Germany, in the second half of the sixteenth century, that this branch of art was cultivated. The town of Augsburg excelled all others. Its artists in this department, who bore the name of *Plattner*, have carved with their fine chasings in alto-relief a number of handles of swords and daggers, and enriched with bas-relief the scabbards of swords, furniture and domestic utensils; and some even carved detached statuettes.

Electrography is a new method of engraving, and has for its principal object to convert into an engraving in relief all drawings made with a greasy, a bituminous, or a resinous body upon a metallic plate. Amongst all metals, zinc is the most proper for this

kind of engraving, and its low price renders it still more desirable. It may be drawn upon with a crayon, with lithographic ink, the surface having first been grained with sifted sand (after the manner of preparing stones for lithography) or with any substance used in drawing on stone. The plates once drawn upon are prepared in the way usual with stones from which impressions are to be taken; zinc plates having often been employed instead of stones, and it is to Senefelder himself, the inventor of the lithographic art, that the application is due.

Zinc, in its natural state, has a great affinity for greasy substances, and for this very reason can be easily drawn upon; but once prepared by plunging it for a minute into a simple decoction of gall nut, and afterwards covering it with a solution of gum Arabic, this affinity is lost.

This process has advantages not possessed by lithography as usually followed; for the action of the acid, exercised both on the ink and the stone, injures the half tints; but the decoction of gall nut, while it makes an excellent preparation, exercises no ulterior action either upon the drawing or the plate.

One remarkable feature in this species of engraving is, it is unalterable; for after the application of the decoction, the drawing remains exactly the same as when it came from the artist's hand. And the importance of this new invention is chiefly shown by the facilities which it offers for producing, like ordinary types, an almost unlimited number of impressions. Zinc is as hard as copper, and with copper stereotypes millions of impressions may be struck off; nor is there any reason for supposing that zinc stereotypes would prove less serviceable. In electrography the work of the draughtsman is not more difficult than when drawing on wood, while that of the engraver disappears, and the extraordinary degree of perfection which can be obtained, together with the surprising celerity with which it can meet the various exigencies of the moment, cannot fail to add to its importance. And while electrography offers precisely the same facilities in its execution as lithography, and exceeds it illimitably in its powers of production, and, as compared with line engraving, it has all the advantages of a far more facile execution, of a

greater variety of style, resulting from the use of crayons, of a typographical use of the press, and of a faithful representation of the artist's labors.

An interesting operation in the manufacture of steel is that of forging a bar of this metal into knife blades. Long habit and constant practice can alone enable the workman to form the blades neatly and with the requisite degree of precision and dispatch.

A penknife blade is formed at two heats; first the *blade*, properly so called, which is hammered out and then cut off the end of the rod, when it is taken up with a pair of tongs, heated again in the fire, and the *tang*, or part by which it is held while grinding and ultimately to be fixed into the haft, is fashioned. The whole is then smartly hammered after it has ceased to be soft, in order to close the pores, and produce the greatest possible degree of density; then having been struck with the nail-mark and the maker's name, or some other device, from a steel punch, the blade is ready for hardening. The steel springs for the back, and iron scales for the inner sides of jointed knives, are made by workmen ranking a degree below the blade makers.

In forging most of the large articles, such as table knives, and edge tools generally, two men are required to manage the forging operations, the one managing the *heat* (as the glowing piece is called) with his left hand, while he uses his hammer with his right, the latter wielding a heavy sledge hammer, with which he alternates strokes with the maker. Table knife blades are composed partly of iron and partly of steel, the two metals being united at the neck or shoulder of the blade. The cutting portion of the blade is first hammered out of a rod of steel; it is then cut off, the thicker end inserted in the fire along with a rod of iron brought to a white heat; the two pieces are then welded together, and the tang and bolster (the part which rests upon the handle) are formed.

The blade, thus properly formed by the hammer, is submitted to the routine of hardening and tempering. On the care and nicety with which these are performed depends the quality of the instrument when completed. It is hardened by plunging it sud-

denly, when red hot, into cold water; and to temper it, it must be again heated till the surface assumes a violet tinge. The hardening of the metal does not depend upon its being immersed in a liquid of any kind, but may be equally effected by the application of cold, and a thin blade may be hardened by placing it when heated between the anvil face and hammer, if both are cold.

The next process is the grinding on a stone that, when first put into the trough, is about four feet in diameter and nine inches across the face. Such a stone, in the course of ten weeks, will be ground down to the diameter of twenty inches, when it is split into two small stones for the scissors grinder's purpose.

After the blade has been ground down on the stone, it is subjected to a finer grinding on wheels coated with emery, and during this, as well as the preceding process, a brilliant stream of sparks is elicited from the steel in contact with the grit or the emery. The polishing and buffing is also performed on a wheel, covered with soft leather, dressed either with fine sand or very fine emery. The grinders are always liable to accidents from the bursting of stones, which frequently fly in pieces with a force that carries every thing before it. To diminish this danger it has become a general rule to affix against each side of the stone a stout iron disc, or large circular plate, through which the axle passes. This contrivance tends very much to counteract the tendency on the part of the stone to fly. But there is another danger to which the grinder is exposed, and from which he cannot well escape, and that is, the continual inhalation of minute particles of dust and ferruginous matter evolved from the stone, especially during the process known as dry-grinding. Among fork grinders it is very rare to meet with an individual thirty-six years of age. Various plans have been adopted to diminish this evil, and while none of them have been entirely successful, the grinders generally have been opposed to the use of covers made of gauze, to be worn over the mouth, or any other contrivance designed for their good, on the ground that any thing that tends to diminish the danger to which they are exposed, would also deprive them of the additional wages the unhealthiness of their employ-

ment now secures to them; and so they continue to inhale the dust, become reckless, knowing that they are doomed to an early grave, and die by the time they come to maturity.

The various uses to which iron is now put are beyond all calculation, and it would be idle for us to attempt the enumeration of all its excellent qualities, for articles both ornamental and useful. For the latter purpose it is chiefly employed, and while it is frequently ornamented, or, rather, covered with devices that are designed to answer that end, we rarely see any thing in this metal which will stand the test, if aught save utility be taken into consideration. But no better evidence of its adaptation to ornamental purposes is required than the open-work tazza, on page 25, from the Royal Berlin Foundry. Here we have in iron, such iron as is daily worked up in our foundries, an elaborate and delicate design, conceived in good taste and worthy of being produced in bronze. The forms used are graceful, the lines sharp and clear, and the effect it produces at the first sight will always be lasting. This is not the case with the generality of castings. We have not yet learned that quantity is not quality, that an excess of ornaments is a violation of good taste, and that whatever has nothing to do, whatever could go without being missed, is not ornament, but is rather deformity and incumbrance.

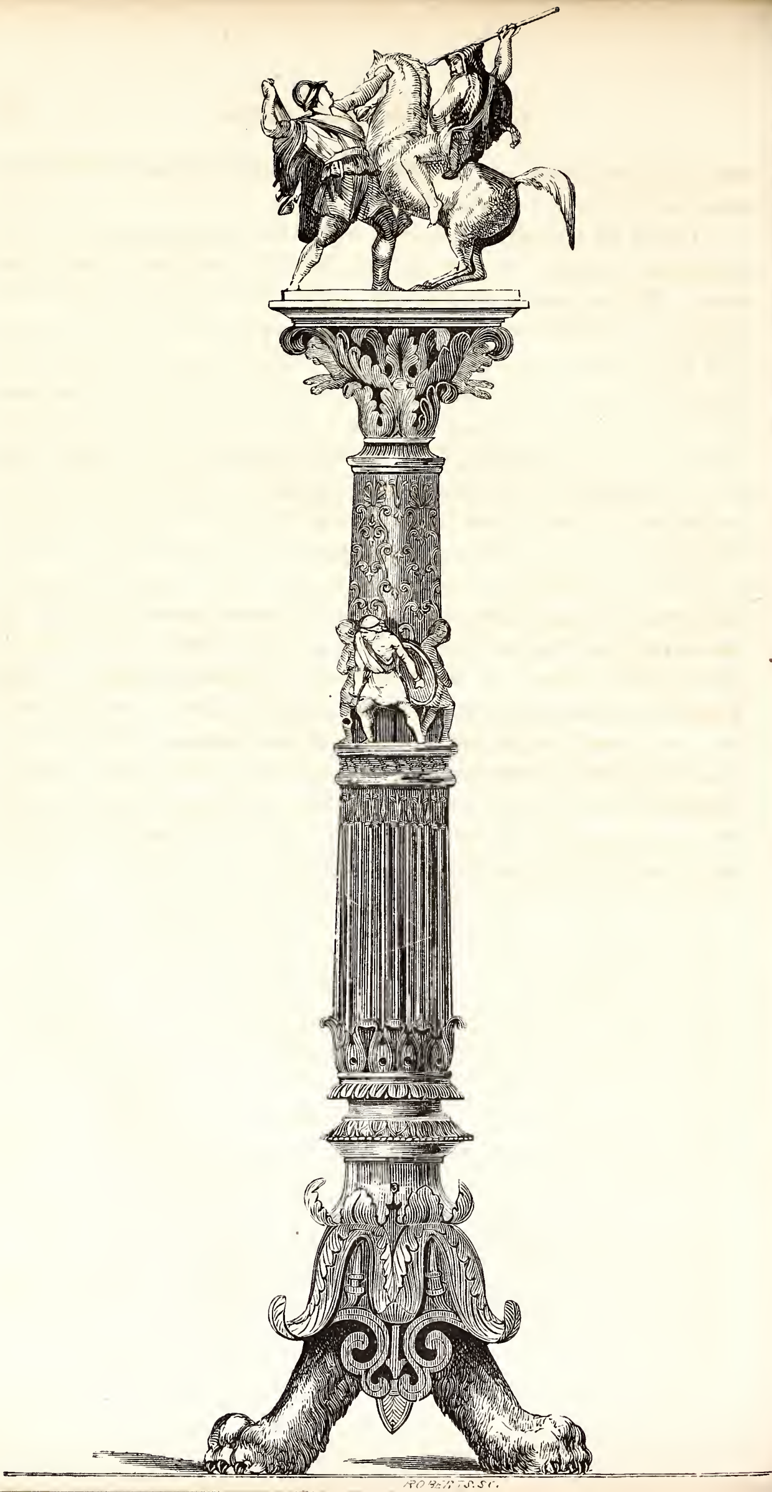
As a general thing, whenever we employ ornaments, and it is particularly so in iron working, we give no thought to the one great principle, that art and utility must go hand and hand, that there is no dividing line between the two, and that whatever has nothing to do is a positive incumbrance. Without attention, then, to the exact adaptation of our materials to the end, and a happy blending of an expression of beauty with fitness, we had better confine ourselves wholly to such forms as are valued only for their utility. A few straight rods of iron would be far more sightly than many of the balustrades in front of our houses; for instead of a meaningless arrangement of angles, curves, and imperfectly moulded natural objects, we should have that which betokened strength and security, with nothing to mar the pleasure of surveying these desirable qualities. But if these same bars of iron were bent into the graceful and speaking forms that

marked the works of Peter Vischer, they would give an additional pleasure in that they bore witness to the intelligence and imagination of the workman.

That which is beautiful in its place may be positively ugly if misapplied. The labor expended on our parlor grates, if properly directed, would give us the choicest designs in place of the excess usually so conspicuous, and which is forced to call in the aid of other materials, only to render our poverty of invention the more marked. Every thing must be in reality what it appears, is a rule with the best designers; how, then, can we accept a design like that of the fire grate on page 39? The central portion is well conceived, and the whole is an excellent example of fine casting; but if we look at the design as a whole, we shall find that the sides are crowded with a profusion of ornaments which give it a confused and heavy appearance, while the landscape vignettes, painted in colors and covered with plate glass, are wholly inadmissible. This is straining after novelty to meet a demand on the part of the public for that which is new and most startling in its effect, and it is also exemplified by a chair leg, which Mrs. Jameson once saw, in which she said a winged seraph was made to do duty as a brass castor, and this was praised as *novel*.

And here let us point to another abuse of iron, which is now growing rapidly into favor for building purposes, and that is, a desire to hide its true character, by painting it in imitation of marble, and even wood; as if the builders were either ashamed of their materials, or were fearful the structure would depreciate in value if it were known that it was constructed of any thing so durable. Surprising as this may seem, we have evidence of the fact wherever iron buildings have been erected.

This subject is already receiving attention, and to no better point could our thoughts be directed. We build a Gothic church and surround it with an iron fence formed of Grecian scrolls; a Grecian temple, for the same purpose, supplied with a gallery supported on Gothic columns. And wherever we turn we see these incongruities, which are passed over, instead of requiring that a building should convey but one prominent idea, carried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out in all its parts, and forbidding all combinations of different eras, so destructive of good taste.

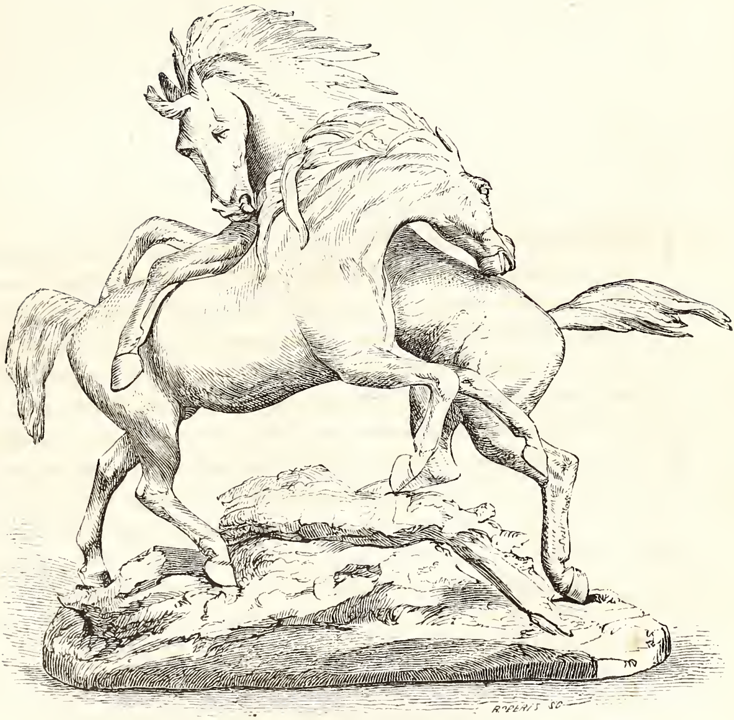
And in all the articles in iron which go to make up the whole catalogue brought to our notice, there is uniformly a want of taste. Hobbs, and Chubbs, may adorn the few locks and keys placed on exhibition in a conspicuous place, but where can we find like articles, displaying the same artistic skill, in daily use? In our iron fences and railings the same idea is repeated over and over again, and our street lantern posts have held up the same skeleton forms since the first introduction of gas, to attest our lack of inventive skill when a field opens for a tasteful display of ornaments. The column here presented, from the Royal Berlin Foundry, we do not offer as a substitute, but to show how readily iron may be adapted to artistic purposes. The shaft rises gracefully from a tripod base, and midway it is encircled by figures in bas-relief; and the flat top supports an equestrian group. Above the central figures the dark color of the iron is relieved and gracefully ornamented by an inlaid thread of silver, wrought into the chaste and simple forms of antique decorations. Objects like these we cannot have at every corner; but surely there is an intermediate step between a column thus artistically proportioned, and the spindling shafts that serve alike to light our steps by night and to disfigure our streets by day.

CHAPTER V.

BRONZE.

THIS compound must have been known at an early period in the history of the world, but nowhere in the Scriptures do we find mention made of it, while from the book of Genesis to that of Revelations, reference is constantly made to brass, which is with us a different metal. We designate as bronze a compound of copper and tin, and as brass a compound of copper and zinc; but the ancients knew nothing of zinc, hence their brass must have been in reality our bronze, and all the specimens exhumed in Egypt, Assyria, and Greece, confirm this when subjected to a test, by yielding only copper and tin, with an occasional admixture of some more precious metal. Less than a century ago, zinc was not considered as a metal at all, and by some it was believed to be a compound of iron and tin, just as the alchemists of old considered tin to be a mixture of silver and lead. The ancients certainly had mines from which they dug the ore of zinc, regarded by all as an earth, which, combined with copper, produced a gold-colored metal. These mines were held in high estimation, and when they became exhausted the loss was deeply regretted, as it was supposed that the metal could never be found again.

Corinthian brass ranked very high, and its superiority was attributed to the quantity of gold and silver it contained. The tradition is that whem Mummius destroyed Corinth, 146 B. C.,



GROUP IN BRONZE.

the great conflagration melted all the statues in the city, and the compound formed the highly valued metal long known as Corinthian brass. But history does not sustain this, for Mummius caused all the valuable statues found there to be carried to Rome, and long anterior to the destruction of the city by his troops, Corinthian brass was well known and highly prized. The speci mens of Corinthian brass that have been analyzed have yielded copper and silver. These two metals readily combine and form an alloy, but it is not so with copper and gold, and the attempts to combine these two in any quantity, have failed, the copper uniformly rejecting, in cooling, all but a small per centage of gold.

Copper, the basis of the compound we have now under consideration, is widely spread over the face of the earth, and man, in all ages, has adapted it to his wants. It was one of the greatest articles of commerce with the Phœnicians, who derived a large supply from the mines of Nubia, that at one time supplied the whole of the known world, and combined with it the tin obtained from the islands of Great Britain. It was used by some of the northern nations of Europe, in the fabrication of weapons, at a period and under circumstances when steel appears to have been more precious than gold. This has been illustrated in Denmark, by the opening of many Scandinavian tumuli of very remote ages, and from which have been collected specimens of knives, daggers, swords, and implements of industry, which are preserved in the museum at Copenhagen. There are tools of various kinds, formed of flint, or other hard substance, in shape resembling our wedges, axes, chisels, hammers, and knives, the blades of which are of gold, whilst an edge of iron is attached for the purpose of cutting. Some of these tools are formed principally of copper, with edges of iron, and in many of these implements, the profuse application of copper and gold, when contrasted with the parsimony evident in the expenditure of iron, seems to prove that at that unknown period, and among the unknown people who raised these tumuli, gold as well as copper were much more common products than iron.

The Mexicans and Peruvians were wholly unacquainted with

the use of iron, and their carvings were all wrought with copper tools. They, however, contrived to harden them with an alloy of from three to seven per cent. of tin. It, nevertheless, seems incomprehensible how their extensive works in granite, porphyry, and other obstinate materials, could be carried on with such aids. The Hindoos, long anterior to their intercourse with Europeans, made their idols from copper. The Egyptians, although not ignorant of iron, were compelled by a variety of circumstances to use copper tools, and with these many of their gigantic labors were effected. They must of necessity have had some means of hardening the metal; yet it is a singular fact, that, with the exception of a few bronze weapons of comparatively late date, the chisels and other implements found in the monuments and at the quarries, are pure copper.

The North American Indians evidently obtained their supply of copper from the shores of Lake Superior, where evidences of their mining operations are frequently brought to light. The great Ontonagon mass of virgin copper, now deposited at Washington, when found, exhibited marks of having had considerable portions cut from it, and the ground around it was strewed with fragments of stone axes and hammers, which had been broken in endeavoring to detach portions of the mass. It is thought that this mass was brought to the surface by the ancient miners.

The greatest known deposit of copper in Europe, discovered in 1561, is in Cornwall, England, where there are upwards of fifty mines, some of which have been worked since the reign of William III. The mines of Sweden are also famous for their copper. Many copper mines have reached an extraordinary depth. The Tresavean mine has reached the extended depth of two thousand one hundred and twelve feet under the surface, and about seventeen hundred feet below the sea. The Eselschact mine, at Huttenberg, in Bohemia, now inaccessible, was deeper than any other mine, being no less than three thousand seven hundred and seventy-eight feet below the surface. Its depth is only one hundred and fifty feet less than the height of Vesuvius, and it is eight times greater than the height of the pyramid of Cheops.

The ores in Cornwall are found both in granite and slate rocks, and when they are brought to the surface, often from a depth of one hundred and sixty fathoms, they are prepared for the smelting house by a process of stamping by means of machinery, which reduces the ore to a powder; it is then subjected to a washing which separates the earthy matter from the metallic portion. Then follows the roasting of the ore, which is conducted after various ways, either by roasting in the open air, which is the most simple process; roasting executed between little walls, which may be called case-roasting; or, roasting in a furnace very like to that in which porcelain is baked. When this is done, the usual way is to place the fuel on the exterior of the furnace, in a kind of brick shaft, and the flames traverse the broken ore with which the furnace is filled. In the flues the sulphur that is volatilized is collected. All that remains of the ore is smelted in contact with the fuel. The iron present in the ore, not being so easily reduced or fused as the copper, remains in the scoria while the copper is run out. Copper often requires to be repeatedly fused, and even then it may still be alloyed with portions of metals which are not volatile, and are of easy fusion; thus, the copper of commerce is never altogether pure, but generally contains a little lead, and a small portion of antimony. The carbonates of copper, reduced by fusion in contact with the fuel, afford a pure copper, as does also the solution of sulphate of copper, which is met with in some mines, the copper being precipitated in its metallic state, by immersing iron in the solution, and it is afterwards fused. In sheathing copper there is a great difference, and this is all traceable to the smelting process; for if every foreign substance, but silver, is not removed, corrosiveness easily takes place; the salt water acting much more readily on the iron and other foreign substances than on the pure copper.

Native copper, like the metal, is of a red color, but frequently tarnishes. Its lustre is metallic; it is flexible, ductile, and malleable, and its fracture is hackley. It is found in the veins of primitive rocks, and of the oldest secondary. Occasionally it is accompanied by several of the ores of copper, and sometimes those of other metals. The Cliff mine, Lake Superior, is one of the most

remarkable known for the enormous masses of native copper that it contains. One of these masses, after it was detached, could not have weighed less than fifty tons, yielding more than ninety per cent. of pure copper—the only impurity being a little rock attached to the surface and rarely included in the copper.*

These masses of pure copper are removed, by finding some place where a hole may be made in the rock, and then firing a heavy blast, tamped by sand. This starts the copper from the wall rock, and sometimes detaches it entirely. The masses are then cut up, by means of steel chisels, driven by blows from a sledge hammer; one man holding the chisel while the other strikes with the sledge. A groove is thus mortised out across the mass, and then a series of ribbons of it, about a quarter of an inch thick, are cut out, until the channel divides the mass. In this way it is cut into portions that weigh from a ton to a ton and a half each. In commencing the operation short chisels are used, whereby much power is saved that would be lost by a long chisel, the elasticity of the latter diminishing the blow. Chisels of greater length are supplied as the work progresses in depth, until, in some of the thick masses, one of four feet is required. This is the case frequently, as masses three and three and a half feet thick are often cut out.

In the copper ore of that region there is much silver. The larger portions are picked out by hand. Where there is only a moderate quantity of silver in copper, it is not extracted, but the copper, when fused, is greatly improved, for the silver prevents its rapid corrosion by sea water, and it gives it more strength, and renders it more valuable for making bronze cannon, the metal proving unusually tough and strong. It has also proved of excellent quality for making church bells, the silver greatly improving the tone; but when a large proportion of silver exists in combination with the copper, it makes it too hard.

* A mass of copper, forty-six feet long and eighteen feet wide, and of a thickness varying from three to nine feet, has been thrown out at the Minnesota mine. It contains about five hundred tons of pure copper, worth, when prepared for market, about three hundred thousand dollars.

Copper may be purified by melting one hundred parts with ten parts of copper scales (black oxide), which are the product of every large manufactory where the metal is worked, along with ten parts of ground bottle-glass, or other flux; and after the copper has been kept in fusion for half an hour, it will be found at the bottom of the crucible, perfectly pure; but the iron, lead, arsenic, &c., with which the metal is usually combined, will be oxidized by the scales, and will be dissolved in the flux or be volatilized. For this discovery the Society of Arts awarded a gold medal.

Copper has many singular properties. Try to drill it, try to file it, try to cut it, to plane, to planish, or to roll it out, or try to stretch it over a mandrel. These things may all be done, but only by an expert hand. In one case you must soothe the surface with oil, or with tallow and wax; in another, the least smear of oil causes it to buckle up, and all is spoilt. Under one operation a bathing of milk is good; in another, a touch with the workman's saliva is more effective than any thing else. The tool applied to it must be neither hard nor soft, beyond the limits of a straw tempering. Anneal it, and kindly it comes forth from the furnace and yields itself to the workman's will, but indiscreetly strike it a few times with a hammer, and in an instant the entire mass undergoes a transformation, and becomes sonorous, elastic, non-plastic, in a word—unmanageable.

If the least drop of water touch the melted ore, it will fly about like shot from a gun. A grain of copper dissolved in alkali, as pearlash or soda, will give a sensible color to more than five hundred thousand times its weight in water. Copper may be forged into any shape, but will not bear more than a red heat, and frequent heatings are required. At a white heat it melts, and if slowly cooled it may be crystallized. At a high heat it burns with a green flame. Exposed to the air, at a natural temperature, it is converted into a green rust, which is the oxide combined with a portion of carbonic acid. In alloying gold for coins, twenty-two carats of gold and two of copper are fused together; and a pound troy of silver, of two hundred and forty

pennyweights, has eighteen pennyweights subtracted, and the same quantity of copper substituted * in its place.

Copper is much more malleable than it is ductile, so that far finer leaves may be obtained than wire. In tenacity it yields to iron, but surpasses gold, silver, and platinum in this respect. Nitric acid acts on copper with great energy, the metal attracting a portion of its oxygen, nitric acid gas being disengaged, and the oxide combining with the remaining acid. This solution, when evaporated, affords prismatic crystals of a deep green color. Acetic acid, or vinegar, forms an important compound with copper. Plates of the metal are exposed to its fumes and a crust soon forms, which is the verdigris of commerce. With nearly all the acids copper combines, and most of the salts have a green or blue tint. Thus, when submitted to the action of sulphuric acid, a solution of a blue color is obtained, which, when corporated, crystals in the form of rhomboidal prism are produced, and this salt is the blue vitriol of commerce. The salts of copper are poisonous, and from the fact that albumen will precipitate the oxide, in which state the precipitate is almost inert, the white of eggs has been recommended as the antidote.

Copper and arsenic form a white-colored alloy, sometimes used for the scales of thermometers, barometers, &c. To form this compound, successive layers of copper clippings and white arsenic are put into an earthen crucible. If two parts of arsenic and five parts of copper have been used, the resulting compound commonly contains one-tenth of metallic arsenic. It is white, slightly ductile, denser, and more fusible than copper, and without action on oxygen at the ordinary temperature; but at a higher heat it is decomposed with exhalations of arsenious acid. If brass plates are used for the same purpose, they may be silvered with a composition of chloride of silver, chalk and pearlash.

* When the copper coins of William III. appeared, a slight tinge in the color of the metal excited the suspicion of those accustomed to examine such things, that it contained gold, which proved to be the fact; hence their real value was greater than that for which they passed current, and they were speedily collected and melted down by the manufacturers, principally as an alloy of gold, whereby every particle of that metal which they contained was turned to account.

The white copper of China is found to consist of one half copper, and the other half in nearly equal proportions of zinc and nickel, with a small quantity of iron. It costs in China about one quarter of its weight in silver. The alloy is nearly silver-white, and is very sonorous. It is malleable at a natural temperature and at a red heat, but when heated to whiteness it becomes brittle.

Yellow brass is composed of seventy parts of copper and thirty of zinc. The specific gravity of brass is greater than the mean density of its constituents; but if heated and quickly cooled, it becomes somewhat less dense. It is not malleable unless hot; when cold it breaks, and after it has been melted twice is no longer in a condition to bear the hammer at all, and to work it lead is added, as also a small proportion of tin.

Brass is manufactured in several ways, according to the use to which it is to be applied. The finest kind is made of what is known as shot copper. This is granulated, which peculiarity is produced by pouring the melted copper into a cistern of water, through a ladle full of holes; and the water must be hot or cold, according to the form wished in the grains. When it is hot, round grains, the description used in making brass, are obtained, and are called bean shot. When the copper falls into cold water, perpetually renewed, the granulations, which are irregular and thin, are called feathered shot.

The calamine, the ore of zinc usually employed in connection with the copper, is reduced to a fine powder in the stamping mills; it is then sifted and washed, to free it from all impurities. It is next mixed with pieces of charcoal or small coal, and subjected to a process of calcination, when it is again ground, with charcoal mixed with the copper, and firmly compressed into a crucible. The compound is exposed in a brass furnace to a degree of heat sufficient to melt the copper, but as the calamine is very volatile, it is necessary to prevent its escape by luting on the cover of the crucible with a mixture of sand, clay, and animal matter. By a cautious management of the fire, and after a continuous exposure to the operation of the heat for a period varying from ten to twenty hours, the mass is thoroughly united, when

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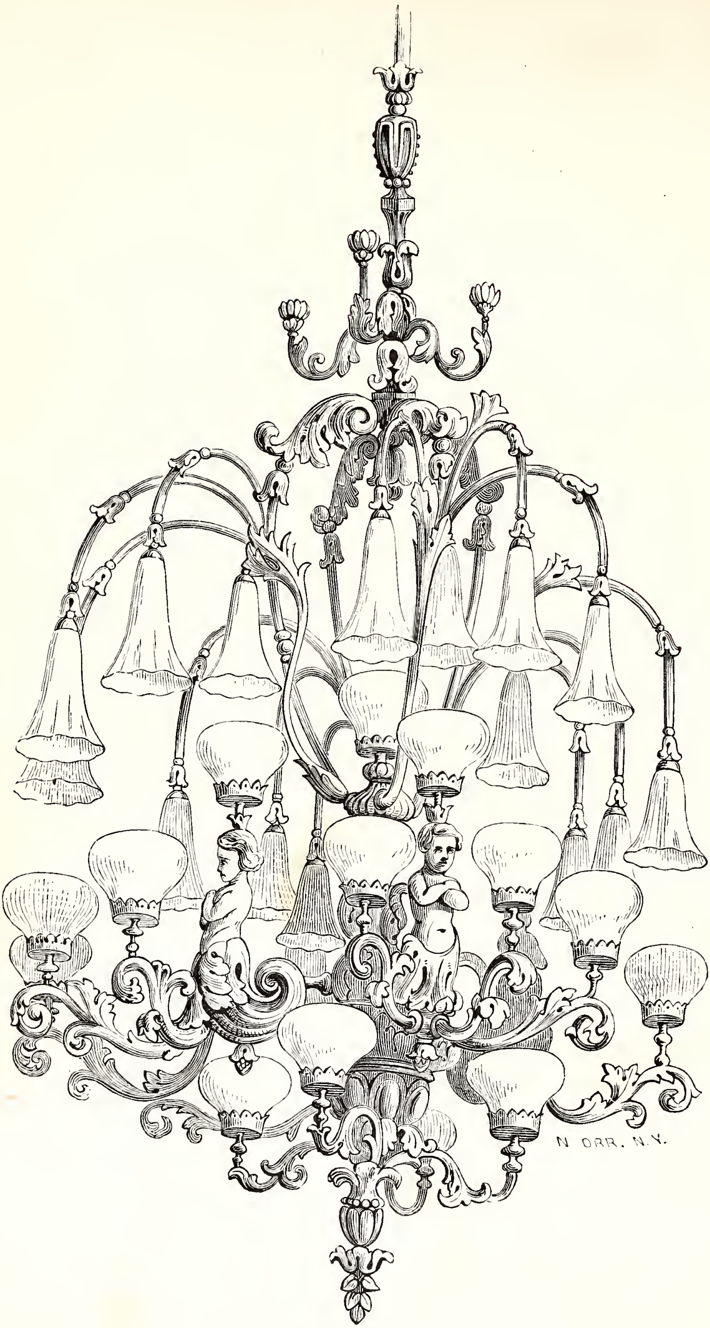
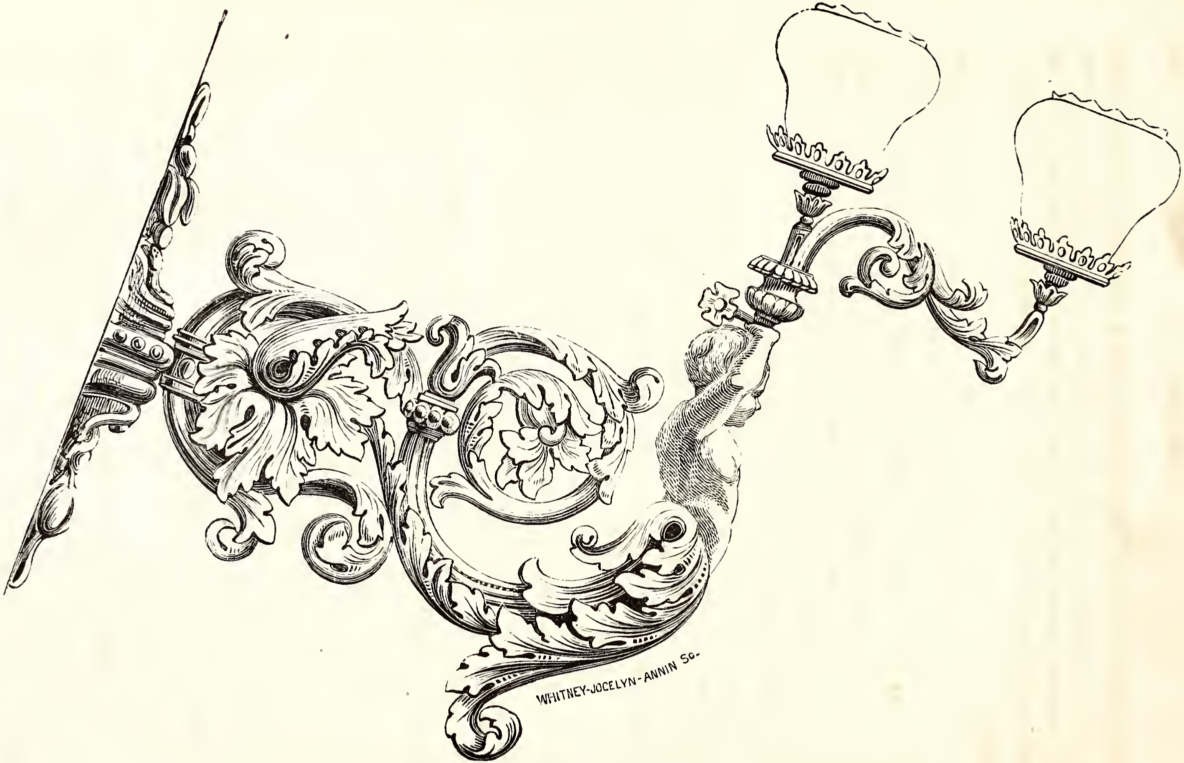
the melted brass is poured into cast-iron ingot moulds, and is ready for market.

Red brass is produced by using not more than twenty per cent. of zinc. Prince Rupert's metal, as it is called, is made of equal parts of copper and zinc. Pinchbeck is formed by adding two parts of copper to yellow brass. This metal was so called from one Christopher Pinchbeck, a celebrated astronomical and musical clock-maker, who invented it, and for some time retained the secret. Speculum metal, employed for the reflectors of telescopes, is composed of one hundred parts of tin and two hundred and fifteen of copper. Or-molu, or mosaic gold, is made by combining fifty-two or fifty-five parts of zinc with forty-five or forty-eight parts of copper. The patent for this beautiful alloy, which now enters so largely into the art-manufactures of Europe, was secured in 1825. In preparing it, equal parts of copper and zinc are melted together at the lowest temperature at which copper will fuse, and after these are stirred together, a further quantity of zinc is added in small portions, until the alloy in the melting pot becomes of the right color. If the temperature of the copper be too high, a portion of the zinc will fly off in vapor, and the result will be merely spelter or hard solder; but if the operation be carried on at as low a heat as possible, the alloy will assume first a brassy yellow color, then, by the introduction of small portions of zinc, it will take a purple or violet color, and will ultimately become pure white, which is the appearance of the proper compound in its pure state. It may then be poured into ingots, but as it is difficult to preserve its character when re-melted, it should be cast directly into the figure moulds. The mosaic gold of the old chemists, is sulphuret of tin.

Cannon metal is composed of ninety parts of copper and ten of tin, to which must be added a small quantity of zinc and lead, at the second melting. Bell metal consists of three parts of copper to one part of tin, and in connection with these gold and silver have also been employed, but always in small quantities, to enrich the tone. The proportions of bronze are, copper eighty-two parts, zinc eighteen, pewter three, lead one and a half. This bronze ad-



CHANDELIER—BRONZE GILT.



BRONZE GAS BRACKET.

p. 24

mits of gilding, but if there be too much copper, it takes more gold; if too much zinc, the fine yellow in the gold color is lost. The proportions of large objects, such as the column of July, at Paris, are, copper 91.43: zinc 5.53: pewter 1.70: lead 1.37—100.00.

Articles of bronze gilt are usually of a light and graceful design, presenting a varied form, that will display the gilding in strong contrast with the darker ground of the bronze, without injury to the general effect. The chandelier here presented, and which is of American manufacture, combines these qualities. The bronze of which it is made has a tint of rich deep green, relieved by the gilding applied to the ornamental parts.

And here we may remark, that twenty years ago, all the finer chandeliers and lamps used in this country were imported from Europe; but at the Exposition in London, in 1851, these articles, of American manufacture, were highly approved for their lightness and purity of design. On the opposite page we give another sample of these goods. It is a gas bracket of four lights, though only two are given in the engraving. The bronze is heavily gilt, and the ornaments, which are most appropriate, are good specimens of the style known as the Renaissance.

In melting bronze much care is required to prevent the tin, which is a volatile metal, from being lost. An incautious founder might commence his work with a bronze of the best proportions, and conclude with nearly pure copper—the tin having passed off in the oxide of tin in the furnace. A curious example of this is given in the column of the Place Vendôme, Paris. The government supplied gun metal, which contained more than ten per cent. of tin. An analysis of a portion of metal taken from the base gave only six per cent.; from the shaft of the column only three per cent.; while the metal of the capital was found to be nearly pure copper.

The surface of the melting metals should be covered with small charcoal or coke; and when the zinc is added, it should be dexterously thrust to the bottom of the melted copper. Immediately after stirring the melted mass, so as to incorporate its

ingredients, it should be poured out into the moulds. In general, the metals most easily altered by the fire, as the tin, should be put in last, and the cooling in the moulds should be as quick as possible, to prevent the risk of the metals separating from each other, in the order of their density, as they are very apt to do.

ENAMELLED CHANDELIER.

p. 83.

CHAPTER VI.

BRONZE STATUES.

The art of casting bronze statues is traced to the remotest antiquity, but it was not till Rœcus of Samos invented modeling that it began to display the refinement which marked the productions of a later period. In Samos, it is supposed, statues worthy of the name were first cast in bronze, and it was there that Theodorus, who shares with Rœcus the honor of improving the method of casting, made the statue of the Pythian Apollo, for the temple of that island. It was made in two parts—half at Samos and half at Ephesus—and then brought together. The colossal statue at Rhodes, reckoned one of the seven wonders of the world, the work of Chares of Lindus, was made 290 B. C., and twelve years were employed in its construction. Chares had scarcely half finished his work, when he found that he had expended all the money received for the whole, which overwhelmed him so completely that he destroyed himself, and the task of completing it was assigned to Laches, one of his fellow countrymen. It was of bronze, one hundred feet in height, and was dedicated to Apollo. The figure stood upon two moles, so placed at the mouth of the harbor that a vessel could pass between the extended legs. A winding staircase ran to the top of the statue, from which point the shores of Syria could be discerned, and the ships that sailed on the coast of Egypt. After standing sixty-six years it was thrown down by an earthquake, and was finally destroyed by the

Saracens, A. D. 672, and the metal, no less than seven hundred and twenty thousand pounds in weight, was sold to a Jewish merchant, of Edessa, who transported it to Alexandria. Nero had a statue of himself, one hundred and ten feet high, cast, and Zenodorus was called to Rome for that purpose. On the downfall of that emperor it was dedicated to the sun. The first equestrian statue founded at one cast, was that of Louis XIV., in 1699, erected in the Place Vendôme in 1724, and destroyed in 1792. It contained sixty thousand pounds of metal, and was the most colossal ever made. The first equestrian statue erected in England was that of Charles I. in 1678. It was cast by Le Sueur, at the expense of the Howard-Arundel family, in 1633. During the civil war parliament sold it to John River, a brazier, with strict orders to break it to pieces; but he concealed it under ground till the restoration, when it was erected in 1678 on a pedestal executed by Grinlin Gibbons.

Bronze statues are not cast solid, and the mould prepared for the purpose is made of three parts—the core, the wax, and the cement or shell. The core is the centre of the figure, which is a rude representation of it, as will be observed in the darker portion of this cut. When it is intended to cast a colossal statue, this core is supported by a framework of iron. The rude outline statue, as we might call it, is usually formed of a mixture of plaster of Paris, brick dust, and a tenacious clay, which, when constructed, is thoroughly dried in an oven. The core is then covered with a layer of wax (represented in the cut by the white line) which is in no part less than an inch in thickness. The artist now works out his design with great care, the perfection of the finished work depending entirely upon the degree of excellence with which this portion of the task is executed. When all is finished, the last coat or shell (outside the white line) is given. This is laid on with great care, and it is composed of some material that will fill with accuracy every fine line, and *set*, or become solid, without suffering any sensible distortion from unequal shrinking. It is generally composed of clay and pounded crucibles. These materials are dried, very finely powdered, sifted, and then mixed to the consistency of thick cream with water

PROCESS OF CASTING IN BRONZE. p. 86.

This mixture is spread over the figure in a series of layers, until the required thickness is obtained, which varies with the size of the casting. After which a very thick coating of a coarser composition is applied, and the whole firmly fixed in a properly prepared grate, when a fire is kindled, by which the wax is melted and allowed to escape through openings left for that purpose, while at the same time the clay is thoroughly dried.

Another process is, to model the figure first in clay, and then take a cast in the usual way. Of this cast a cast is taken in plaster of Paris, and when it is sufficiently dry it is cut into sections, and carefully removed from the figure. The moulding wax is rolled out into pieces of the most uniform thickness, and cut into thin strips. The workman now applies the wax to the several sections of the mould, pressing it with his tools into every part; or, in some cases, castings in wax are made in the moulds. Whichever way is adopted, the wax having received the impression of the several parts, is applied carefully to the core and joined together, proceeding from the feet upward, and filling up every space, as the work progresses, with a liquid cement. Thus the form of the statue is always made out in wax, and the thickness of the wax, between every part of the core and the shell, regulates the quantity of metal that the statue will contain.

When the wax is melted out, the shell and the core would fall together, but for a provision which is made by adjusting pieces of metal in the process of putting up the parts, for the purpose of preventing this.

To dry the mould it is subjected to a temperature of 340° or 350° Fahrenheit's thermometer. It is then placed in the casting pit and brought in communication with the furnace, when the metal is allowed to flow, and it at once fills the mould. In large castings it was formerly the practice to cast the parts separately, and unite the sections afterwards by pouring fused metal into the joints, but now it is usual to cast the whole work at once.

After the casting has been completed, and time has been allowed it to cool, it is uncovered and brought to the light, when all the superfluous portions of the metal have to be cut away, and the final finish is then given. This finishing demands the eye of

an artist to guide the hand of the artisan. In Europe it has long been the practice to intrust this portion of the work to artist-workmen—men who have been educated in the industrial schools at the same time as artists and artisans.

The art of casting and chasing in bronze was cultivated in Italy, Germany, and France, during the whole artistic period of the middle ages, and from the eleventh to the fifteenth century castings were produced, but the works that have come down to us from that period are more generally composed of gold, silver, and enamelled copper. It was during the latter part of this period that Lorenzo Ghiberti received his education in art, and on the opening of the fifteenth century (1403), he received the commission for the celebrated gates of the Baptistery of St. John at Florence, which, when completed, Michael Angelo said were worthy to be the gates of Paradise.

Ghiberti was son-in-law to Bartoluccio, and received from that skilful artist the first principles of the arts of design. When scarcely twenty years of age, and having just left the workshop of his father-in-law to go to Rimini, he was recalled to Florence by the latter, to offer himself to the guild of merchants in that city, as a candidate for the execution of the work above named. This was in 1401. Ghiberti had to contend with powerful rivals; among whom Brunelleschi, Donatello, and Jacopo della Quercia were the most esteemed. But, directed by Bartoluccio, who even assisted him, according to Vasari, in the execution of the piece for competition, Ghiberti produced so fine a work that Brunelleschi and Donatello acknowledged themselves vanquished. The judges ratified the disinterested decision of those great artists, and Ghiberti was charged with the execution of these gates, by which his name has been immortalized. The bas-relief of Ghiberti, still preserved in the cabinet of bronzes of the Florence Gallery, was admirable in design and composition; yet, in these respects, that of Brunelleschi, to be seen in the same cabinet, was in no degree inferior. Ghiberti owed his victory to the exquisite and finished execution of his bronze, which had been completed and retouched with all the care which good goldsmiths then bestowed upon the most delicate specimens of their art; and it may

WOMAN AT THE BATH, (BRONZE.)

be safely asserted that it was to his talent as a goldsmith that he owed his triumph in this competition with the greatest sculptors of the fifteenth century.

The execution of the doors of the Baptistery of St. John occupied forty years, and during these long labors Ghiberti took, as his assistants, young goldsmiths, who became, at a later period, skilful masters of the art. His brilliant success obtained for him numerous orders for sculpture; yet he never renounced his original profession, but continued during his whole life to execute works connected with the goldsmith's art. He is justly considered one of the greatest sculptors of modern times; he may also be classed among the first of goldsmiths.

As works of art, Ghiberti's gates are remarkable in several respects: as specimens of figure and ornamental modelling, and of metal casting. The relief is in three degrees, low, middle, and high relief, but so skilfully managed as almost wholly to obviate the difficulty of the shadows of the higher portions interfering with lower and distant objects. In the ornamental architecture on the jambs and traverse, we have some of the earliest skilful natural treatment of the objects introduced, but the whole of these ornaments are conventionally arranged.

The works in bronze of Benvenuto Cellini are also justly celebrated, and he, too, was a goldsmith of the highest order. In the present day, our idea of the goldsmith's art is limited to working upon gold and silver; but during the middle ages, and at the time of the Renaissance, when the precious metals were not so abundant, the goldsmiths worked equally on copper and other metals.

Benvenuto was born in 1500. After spending nearly two years in the workshop of Michael Angelo, to whom he had been apprenticed at the age of thirteen, he was placed under Antonio di Sandro, another Florentine goldsmith, and an artist of great talent. He subsequently worked under different goldsmiths of Florence, Pisa, Bologna, and Sienna, to which latter place he had been banished in consequence of an affray. All the time he could steal from the goldsmith's work he devoted to drawing, and the study of the works of the great masters, particularly those of

Michael Angelo, of whom he was a passionate admirer. At the age of nineteen he went to Rome. During the two years he passed there, on this his first visit, he devoted himself almost exclusively to the study of its antiquities, which he only relinquished to work at the goldsmith's art when he found himself in want of money. It may be easily imagined that by following this course, Cellini, who was endowed with great intelligence and a lively imagination, soon became a distinguished artist.

His most celebrated works in bronze are, the statue of Perseus, and the fine bust of Cosmo I. The statue of Perseus was ordered by Duke Cosmo, for the grand square of Florence, where the works of Michael Angelo and Donatello had already been placed. This Benvenuto esteemed a high compliment, and he promised that the work should greatly excel the model which had so much pleased the Duke. But his rivals were so incensed on learning this, that they put every obstacle in his way to success, all of which he surmounted; and to this day his statue stands in the square at Florence, a monument of his genius and indomitable perseverance.

In the sixteenth century, the Florentine sculptors made a large quantity of small bronzes, statuettes, or bas-reliefs, copied mostly from the antique, or from the masterpieces of contemporary artists. Some of these were executed by the great masters of that period. Works of rare beauty, executed in silver and gold, have been copied with great fidelity in bronze by workers in that metal of the present day, and we here present a vase of French workmanship, after a design by Benvenuto Cellini. In casting objects of this description the French greatly excel all other nations, and it is estimated that no less than six thousand persons are employed in Paris constantly in making articles of bronze, for home consumption and exportation.

Germany possesses a considerable number of funeral monuments in bronze, of the fourteenth and fifteenth centuries. Peter Vischer, the most famous of the German sculptors, who, at the beginning of the sixteenth century, first introduced into his own country the Italian style of the Renaissance, had before executed

ORNAMENTAL VASE—BRONZE.

very fine tombs of bronze, stamped with the Germanic style of the middle ages.

For thirteen years, Peter Vischer, with his five sons, worked unceasingly on the bronze shrine of St. Sebald, which is now one of the chief attractions of Nuremberg. The oaken case in the centre he adorned with plates of silver, and surrounded with Gothic architecture of the most florid kind. And when completed, he placed an inscription upon it to the effect that the work was performed "for the praise of God Almighty alone, and the honor of St. Sebald, Prince of Heaven, by the aid of pious persons, paid by their voluntary contributions;" but the voluntary contribution was miserably small, if we may trust tradition, which makes the entire sum but seven hundred and seventy florins. His own statuette he carved and placed upon the shrine. He is represented with his leather apron on, and chisel in hand, in the act of carving, with head raised and a lofty mein, that must impress most favorably all who look upon this evidence of his skill and and ingenuity. Of his worth a friendly hand thus makes record. "The simple copper-smith who could make plain candlesticks for household use, as well as raise a shrine to the honor of a heavenly prince; a handicraftsman, like many others, but one so learned and skilful that princes delighted to visit him, and the after world has willingly placed him among great artists."

In the middle ages, there were few artists capable of executing the great tumulary slabs upon which were represented the figures of the deceased; but when, in the fifteenth century, a taste for the arts had diffused itself over Germany, and the number of talented artists had greatly increased, it became the custom among private persons of wealth to place upon the tombs of their relatives circular medallions, cast and chased in bronze, having generally for subjects the escutcheon of the deceased, supported sometimes by angels, children, or animals, these bas-reliefs being cut out and perforated, and laid upon the stone slab.

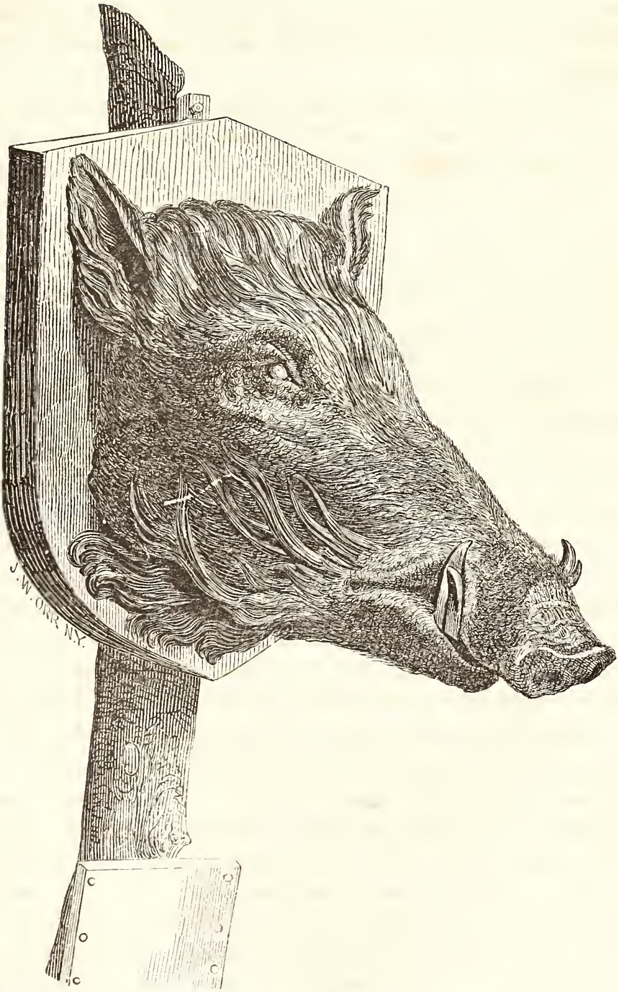
It was principally at Nuremberg that this kind of monument was executed, from the middle of the fifteenth century to beyond the seventeenth, of which the old cemetery of St. John, in that town, where Albert Durer is buried, affords abundant testimony.

It contains a large number of tombs, enriched with medallions, cut out in such a manner as to form a relief upon the stone; several of these are of a very elevated style of composition, uniting great purity of design with workmanship of exquisite delicacy.

The tombs of Luther and Melancthon are both in the castle church at Wittenberg, and it is known that to those who desired to destroy these tombs, after the capture of the town, the Emperor Charles answered, "I war against the living, not against the dead." It was to the portal of this church that Luther affixed the famous protest against indulgences, which occasioned the first movement of the Reformation. The king has caused two doors to be cast in bronze, with the protest inscribed on them, so that it will now be seen there in imperishable characters.

Castings of natural objects are made with a fidelity that must surprise all who are not familiar with the process. Here are two specimens of this class, the one a boar's head, and the other a Crassula portulacöides, executed in Florence, and were never subjected to any finishing process.

Castings of this kind may be obtained in the following manner. A bird, for instance, is taken and placed in some natural position, and suspended, if necessary, by means of fine threads. Once adjusted, a composition of plaster of Paris and brick dust is worked together until it is very fine and soft, and then poured over it till it fills up the whole mould or box in which the object is suspended, leaving only a communication with the bird by means of a hole made with a large iron wire. After the mould has been thoroughly dried, it is fired and the heat around it is gradually increased until it is red hot. This, it must be seen, will consume the object enclosed, and leave only a little ashes in its place, which the workman shakes out of the hole made by the wire; and, for fear that any of the ashes still remain, he fills the mould with quicksilver, which forces every particle of dust to rise to the surface, and the whole is then poured off together. This done, the bronze, in a very fluid state, is poured in; when the mould is cold it is broken up, and in the heart of it a perfect representation of the bird is found, even to the smallest feather that



BOAR'S HEAD, (BRONZE.) p. 92

CRASSULA PORTULACAIDES, (BRONZE.) P. 92.

VASE, BRONZE GILT.

covered its little body. And in no other way could the hairs on the boar's head, and the delicate leaves of the plant, in the illustrations, be thus truthfully rendered.

Small objects in bronze, of exquisite finish and beauty, in the manufacture of which the French excel, are usually composed of several parts, moulded and cast by different hands, but so proportioned and adjusted that they will all combine and make a whole. Thus in the gilt bronze vase here presented; the vase would be moulded by itself, the body having one mould and the cover another; each of the figures would require a mould, and it would be the same with the pedestals and the little feet that support them. And to secure uniformity in the work, a design is made of the proper size and nicely finished; each workman has only to see that his work corresponds with the part set before him, and if it be found correct, there will be no difficulty when the whole are brought together and united by means of solder or small rivets and screws.

Within a few years a process has been discovered for casting ornamental cylinders, such as the body of this vase, without a core. In the ordinary process of ornamental casting it is necessary to have an outer and inner mould, as already described for moulding a statue, so as to leave an interstitial space into which the molten metal is poured. When the metal becomes cold, the outer case is removed and the inner one is broken out. By the new process the outer mould is alone required; the metal envelopes every portion of it at once, and a highly-finished casting is produced in a few minutes. The mould is of brass, and is divided into sections, upon the *inner* surface of which is executed the ornamental design which is to form the *exterior* ornamentation of the cylindrical vessel, whatever it may be. The sections of the brass mould are made hot, and fixed together by being placed in the centres of two discs of metal. Thus firmly secured, the required quantity of metal is poured into the mould; it is then turned upon its side, placed upon an inclined plane and allowed to roll down it, and when it arrives at the bottom it is suddenly turned over, so that all the metal which has not cooled flows out. By this motion the fluid metal has a tendency, in virtue of cen-

trifugal force, to fly forcibly against the sides of the mould. It is therefore urged into every line of the pattern, and there solidifies, the brass mould, though warm, being much colder than the metal. The mould is immediately divided, and a very perfect urn or vase, elaborately ornamented, is produced. By this process as many as a dozen can be cast in an hour, whereas not one could be completed in the same time by the old method. It is peculiarly adapted to castings of zinc and type metal, now so much used for objects of ornamental art, which, when completed, receive a coating of copper applied to every part by means of the electrotype process, which will be fully described hereafter. The statue of the Amazon and Tiger, page 101, is made of zinc, coated with copper, and to all intents and purposes, it may be called a bronze statue, for it has not only the effect, but also the durability of that metal; and another advantage is, its cheapness: articles cast in this way costing only one-sixth the price of bronze. The coloring is effected by applying various chemical preparations, usually containing a salt of copper, such as the acetate of copper or verdigris, and not unfrequently some ammoniacal salts.

Bell casting is an interesting operation, and should receive our attention. The composition, known as bell-metal, has already been described; we shall, therefore, pass on to the founding of the bell, the first principle of which is, to construct and shape it so as to insure that due harmony in all its parts which shall give it its proper degree of tone and vibration.

The shape of the bell is generally governed by a rule, which requires that the thickness of the sound bow or brim, where the clapper strikes, be the standard. The diameter of the mouth should be fifteen brims, the height of the shoulders twelve brims, and the width of the shoulders seven and a half brims. Guided by this rule, the workman prepares the mould, which is divided into as many parts as that already described for a statue—the core, the wax, for which tar and grease are substituted, and the mould, which shuts down over, all and gives the form to the exterior of the bell, called the cope.

The core is first finished, and this is made of rough brick-work, hollow in the centre, and covered over with clay, which is mould-

GROUP OF THE AMAZON.—(KISS.) ZINC CASTING. 94.

ed into form by means of a piece of wood, called a crook, which has a sweep on one edge exactly corresponding with the inner surface of a bell. The upper end is attached to a stick, which passes down through the hollow of the core, and acts as a pivot, so that all sides are made exactly alike as the crook sweeps round, guided by the workman. The core is then baked enough to render it hard, and when it is cool it receives a coat of tar and grease, which is also worked into form by means of the crook, and as the wax represents the thickness of the metal when the statue is cast, so these materials occupy the space that will be filled by the fluid metal when the bell is cast. The crown or head, which contains the parts necessary to hold the clapper, and by which the bell is to be hung, must now be fitted.

The next operation is to fit on the cope, or outer mould. This is formed over all, and of course rests upon the tar and grease, which preparation has already received the exact form of the intended bell. Then the whole (now in the pit) is surrounded with earth and pressed down, leaving two communications with the head, the one for the liquid metal to descend into the mould, and the other for the air to escape. When the liquid metal runs into the space occupied by the tar and grease, these combustible materials are consumed, and the metal, filling up the whole space they occupied, assumes the shape of a bell. When it has cooled sufficiently to allow the workmen to handle it, it is removed to the tuning room, where it is finished off and prepared for use. If it is found too sharp in tone, the thickness of the metal is reduced; and the diameter is lessened in proportion to the substance if it proves to be too flat.

Bells are of great antiquity, and are used alike by civilized and heathen nations. From the Egyptians the Greeks and Romans probably derived their knowledge of them. Of golden bells we find mention made by Moses, and these were attached to the robes of the High Priest of the Israelites. Bells were introduced in Campagna, A. D. 400, by the Bishop of Nola, and into France about 550; and when Clothair besieged Sens, Lupus, bishop of Orleans, caused the bells to be rung, which so frightened the army without the walls that it left in dismay. Pope Sebastian,

who died in 605, first ordered that the hours of the day should be announced by striking the bell, that the good people might better attend to the hours for singing and praying. Bells were formerly objects of superstition. Each one was represented to have its peculiar name and virtues, and many are said to have retained great affection for the churches to which they belonged and where they were consecrated. When a bell was removed from its original and favorite situation, it was sometimes supposed to take a nightly trip to its old place of residence, unless exorcised in the evening and secured with a chain and rope.

The custom of baptizing and naming bells began in the eighth century, and about the year 900 bells were used in churches by order of Pope John IX. as a defence, by ringing them, against thunder and lightning. The first peal of bells was probably that of King's College, Cambridge, presented by Pope Calixtus III., 1456, and consisted of five bells; subsequently the art of producing a succession of musical notes was brought to great perfection. Peals of ten and twelve bells are often hung, but those of five and eight are more common.

The nearer bells are hung to the earth's surface, other things being equal, the further they can be heard. Franklin has remarked that many years ago the inhabitants of Philadelphia had a bell imported from England. In order to judge of the sound, it was elevated on a triangle in the great street of the city, and struck; and, as it happened, on a market day, the people, coming to market, were surprised on hearing the sound of a bell at a greater distance from the city than they had ever heard a bell before. This circumstance excited the attention of the curious, and it was discovered that the sound of the bell, when struck in the street, reached nearly double the distance it could be heard when raised in the air.

In Pekin there are seven bells that weigh each one hundred and twenty thousand pounds; but the great bell of St. Ivans, Moscow, weighs one hundred and twenty-seven thousand eight hundred and thirty-six pounds, while that of the Kremlin weighs four hundred and forty-three thousand seven hundred and thirty-two. This last was never hung. Its height is twenty-one feet four and

a half inches; its circumference, ten feet above the extremity of the lip, sixty-seven feet four inches; its diameter is over twenty-two feet, and its greatest thickness is twenty-two inches. The metal in it alone is valued at £66,565. It was never removed from the pit where it was cast.

In casting bells Burmah transcends all the rest of India. They are disproportionately thick, but of delightful tone. The raised inscription and figures are described as very beautiful. These bells do not flare open at the mouth, like a trumpet, but are precisely the shape of old-fashioned wine glasses. Several in the empire are of enormous size. At Mengoon, near Ava, there is one that weighs more than three hundred and thirty thousand pounds. By actual measurement it is twenty inches thick, twenty feet high, including the ear, by which it is hung, and thirteen and a half feet in diameter. The weight was ascertained by the Burmans before casting, and its bulk in cubic inches proves them to be correct. It is suspended a few inches above the ground, and, like all other great bells, is without a tongue.

The gongs of the Chinese, from the word "tshoung," which signifies "a bell," are forged of bronze with a hammer. They are very thin, and are raised up in the middle. The alloy of which they are composed is as brittle as glass when cast; but by placing it between two discs of iron, to keep its shape, and plunging it at a cherry red into cold water, it becomes tough and malleable.

Bells of cast iron, and steel bells, have been frequently made of a large size. They can be produced in these metals at a lower rate than in bell-metal, but they are very liable to crack. When cast iron is used, a small proportion of tin is added, and the result is a very sonorous metal.

From a description of the process necessary to produce one of the largest objects made from the several alloys referred to, let us now turn to the mode of making a pin, which is also composed of nearly the same materials. The wire, which is made of yellow brass, with the addition of a small quantity of zinc and lead, is subjected to fourteen different operations when worked by hand. And first the workman straightens it and cuts it into

lengths of three or four pins, producing eighteen or twenty thousand pin lengths in a day. Then the pointing is executed on a grindstone by two men; the one giving the rough point and the other finishing it, when the wires are cut into the proper lengths by an adjusted chisel. Then the heads are twisted out of a finer wire, coiled into a compact spiral (round a wire of the size of the pin, by means of a small lathe constructed for the purpose), and two turns are dexterously cut off for each head by a skilful workman, who may turn off twelve thousand in the hour. To anneal the heads, they are put into an iron ladle, made red hot over an open fire, and then thrown into cold water; after this they are stamped by the blow of a small ram, and then they are fixed on to the shanks by men who make from twelve thousand to fifteen thousand per diem, exclusive of one-thirteenth always deducted for waste.

To clean or yellow the pins, they are boiled for half an hour in sour beer, wine lees, or a solution of tartar, after which they are washed. And to whiten them a stratum of about six pounds of pins is laid in a copper pan, then a stratum of seven or eight pounds of grain tin, and so on alternately till the vessel is filled, a pipe being left inserted in the side, to admit of the introduction of water at the bottom without deranging the contents. The vessel is then placed over the fire, and when the water becomes hot the surface is sprinkled with four ounces of cream of tartar, and after the expiration of an hour the pins and grains are separated by means of a kind of cullender. Then the pins are washed, after which they are dried and polished in a leather sack, filled with coarse bran, winnowed by fanners, and fixed in papers previously pricked for receiving them, which last operation is performed by children, who acquire the habit of putting up thirty-six thousand per day.

This is the process usually employed in making pins by hand; but beautiful inventions have been introduced that greatly facilitate the operation. During the war of 1812 an attempt was made to introduce the manufacture of pins into New York; but the low prices that followed the declaration of peace, were destructive to the enterprise. Several subsequent attempts to carry on

the business in this country were made, but with little success till the Howe Manufacturing Company set up an invention in 1835, patented by the head of the house, and the same inventor patented another invention, now in use, in 1846, for making solid headed pins. A patent was also obtained in England, in 1835, by Samuel Slocum, of Rhode Island, but in this country he obtained no patent for a machine invented for the same purpose, and which has been successfully run in secret. This last invention has changed hands, and is owned by the American Pin Company, and this firm and the Howe Manufacturing Company, with one or two other establishments, now manufacture nearly all the pins consumed in the United States. One of these machines turns out two barrels of pins per day, each barrel containing two million pins. It takes the wire from a reel, cuts it into the required lengths, points, heads, and makes a perfect pin by a single operation. From this machine the pins fall into the hopper of the sticking machine, in which they are arranged, stuck into the paper at the rate of three hundred a minute, and come out all perfect, only requiring to be packed, to be ready for market.

It is well known that pins of brass wire are deficient of strength and elasticity, and pins of steel and iron have been introduced as a substitute, but they must be coated with tin. This operation, however, cannot be performed equally well with iron as with brass, and without it the pins have an uneven surface, which renders them inconvenient for use, as they are liable to tear the cloth. To avoid this defect the iron is first covered with a thin coating of copper, or other metal having a greater affinity for tin than iron has; but in order that the result should be satisfactorily attained, it is necessary to polish and pickle the pins before coppering them. This is done in a bath prepared for the purpose, and when it is accomplished sulphate of copper, in crystals, is added, and the whole agitated for ten minutes, when a solid coppering will be effected, with a finely polished surface. The pins are then washed in cold water, put into a tray with a hot solution of soap, and agitated for a couple of minutes, when they may be dried and trimmed in the usual way.

Pins were not known in England till the latter part of the

reign of Henry VIII. (1543.) The ladies used ribbons, loops, and skewers made of wood, of brass, silver, or gold. The pin was at first so ill made that Parliament enacted none should be made unless they had double heads, "and have the heads soldered fast to the shanks of the pynne." After this act few were made. The "pynners" declared "that sens the making of the saide act there hath been scarcitee of pynnes within this realme, that the kynge's liege people have not been wel nor completely served of pynnes;" and they pray that, "in consideration thereof, it maie please the king that the act may be adjudged and decreed from henceforth frustrate and nihilated forever."

A very simple mode of bronzing a medal is, to wash it well with spirits of turpentine, after it has been exposed to a strong heat, by which the turpentine is decomposed and a fine coating of reddish resin deposited upon the surface. Another common mode of bronzing coins and medals is, to apply a solution of sub-acetate of copper and one part of the muriate of ammonia dissolved in vinegar and boiled frequently. In this the metal is placed, and it is necessary to watch it, lest the oxidation of the surface should extend too far, and thus produce a dull granulated face. It is then washed, to remove all the acid, and the process is complete. To produce the *patina antique*, or the fine green crust which is so much admired in antique statues: a composition of one part of sal-ammonia, three parts of cream of tartar, six of common salt, in twelve parts of hot water, and mix with the solution eight parts of a solution of nitrate of copper. More salt gives a yellow tinge, less salt a bluish cast, and an addition of sal-ammonia accelerates the operation. This must be applied in the form of a wash to the surface, and the article must be put in a damp place, to prevent its drying too rapidly. When dry, other washings must be applied, until a fine hard crust of *patina*, susceptible of taking a fine polish, is obtained.

Bronze powders are made by taking slips of copper and dissolving them in aqua fortis. When the acid is saturated the solution is warmed, and slips of iron are immersed in it, by which metallic copper is precipitated in the form of a fine powder.

The Chinese are said to bronze their vessels by taking two

ounces of verdigris, two of cinnabar, five of sal ammonia, and five of alum, all in powder, and when made into a paste with vinegar, spread, in the form of a thick coat, over a surface previously brightened. It is then cooled, washed and dried, and subjected to the same process again till the desired color is obtained. An addition of sulphate of copper makes the color incline more to chestnut brown, and of borax more to yellow.

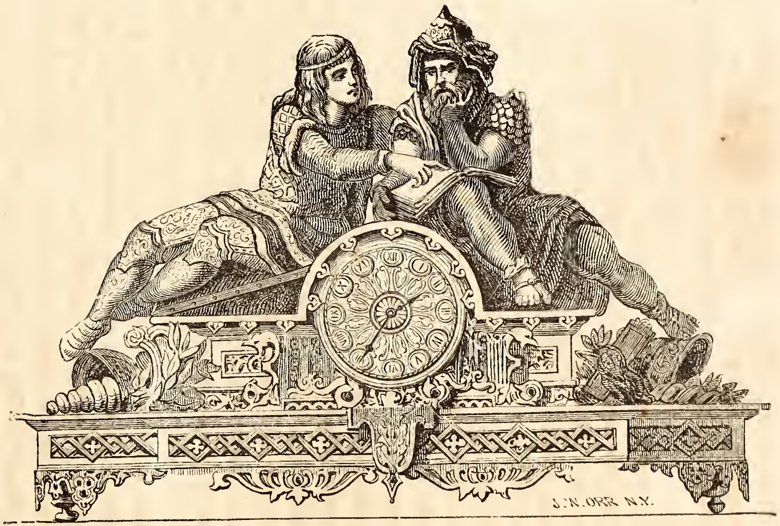
Objects made of gypsum may be durably bronzed, and bear exposure to the weather better than after the ordinary oil varnish, by the following process: Prepare a soap from linseed oil, boiled with caustic soda lye, to which add a solution of common salt, and concentrate it by boiling, till it becomes somewhat granulated upon the surface. Strain through a linen cloth, with moderate pressure, and what is passed through dilute with boiling water, and again filter. On the other hand, four parts of blue vitriol and one of copperas are to be dissolved separately in hot water. This solution is to be poured slowly into the solution of soap, as long as it contains any precipitate. This flocculent matter is a mixture of cupreous soap and ferruginous soap, that is, a combination of the oxides of copper and iron with the margaric acid of the soda soap. The copper soap is green, the iron soap is reddish brown, and both together resemble the green rust which is the characteristic of the antique bronze. When the precipitate is completely separated, a fresh portion of the vitriol solution is to be poured upon it in a copper pan, and is made to boil, in order to wash it. After some time the liquid must be decanted and replaced by warm water, for the purpose of washing the metallic soaps. They are finally treated with cold water, pressed in a linen bag, drained and dried. In this state the compound is ready for use in the following way:

Three pounds of pure linseed oil are to be boiled with twelve ounces of finely powdered litharge, then strained through a coarse canvas cloth, and allowed to stand in a warm place till the soap turns clear. Fifteen ounces of this soap varnish, mixed with twelve ounces of the above metallic soaps and five ounces of fine white wax, are to be melted together at a gentle heat in a porcelain basin, by means of a water bath. The mixture must be kept

for some time in a melted state, to expel any moisture it may contain. It must then be applied, by means of a painter's brush, to the surface of the gypsum previously heated to the temperature of about 200° Fahr. By skilful management of the heat, the color may be evenly and smoothly laid on without filling up the minute lineaments of the bust. When, after remaining in the cool air for a few days, and the smell of the pigment has gone off, the surface is to be rubbed with cotton wool, or a fine linen rag, and variegated with a few streaks of metallic powder or shell gold. Small objects may be dipped in the metallic mixture and then exposed to the heat of a fire, till they are thoroughly penetrated and evenly coated with it.

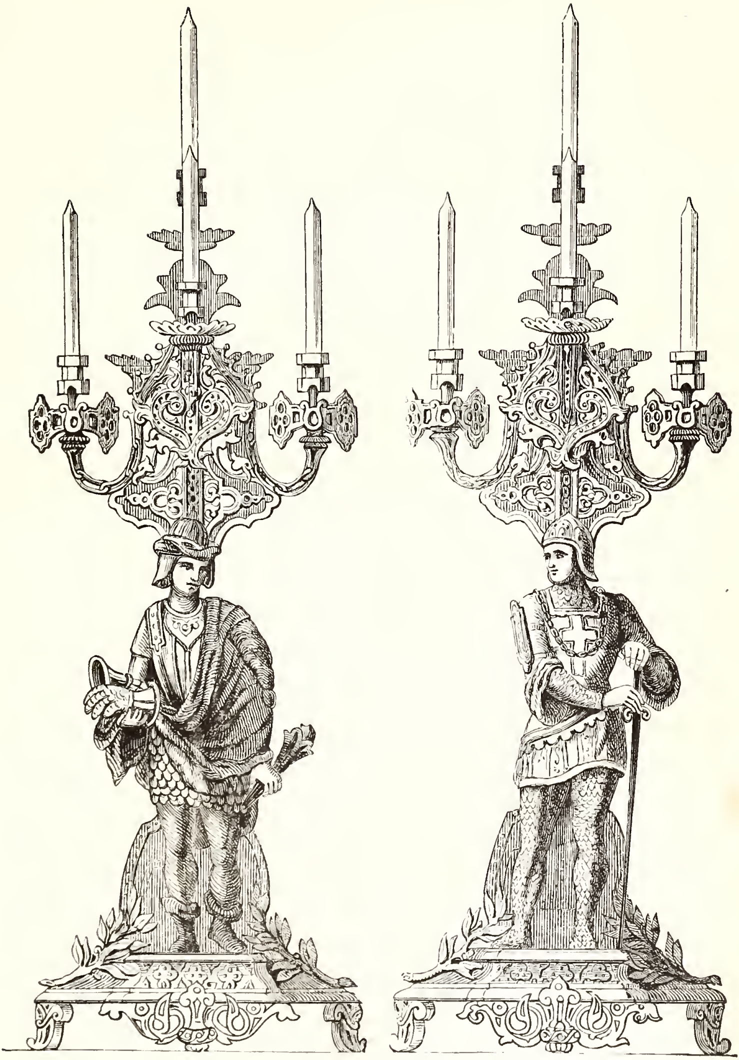
Ornamental articles cast in an inferior metal, may be made to assume the appearance, and, so far as decay is considered, the qualities of bronze, by the new process of electro-brassing, by means of which the surface of cast iron or zinc receives a deposit of the alloy, which may subsequently be treated exactly like bronze. This is effected by means of a voltaic battery, the operation of which will be described in another chapter. This mode is now employed on a most extensive scale, not only for large objects, like the statue of the Amazon, at page 94, but also to the most ordinary objects, even to the facing of printing types with copper, which renders them more durable, and they give a clearer and sharper impression than can be obtained from the ordinary type metal. Many articles now offered for sale, and which have the appearance of being made of bronze, are in reality composed of cast iron, with a bronze surface. An illustration is given in the Baptismal Font, page 46.

Articles of bronze, of the most graceful forms, are now placed within the reach of the many, and the French manufacturers have excelled all others in the variety and finish of works of this description. In the production of mantle ornaments they seem to delight, and these are often marked for the grace and beauty of the design. We here introduce a set, composed of a clock and a candelabrum on each side. The elaborate clock is surmounted by two figures representing the conversion of a Saracen. The whole stands on a perforated and appropriate pedestal. The



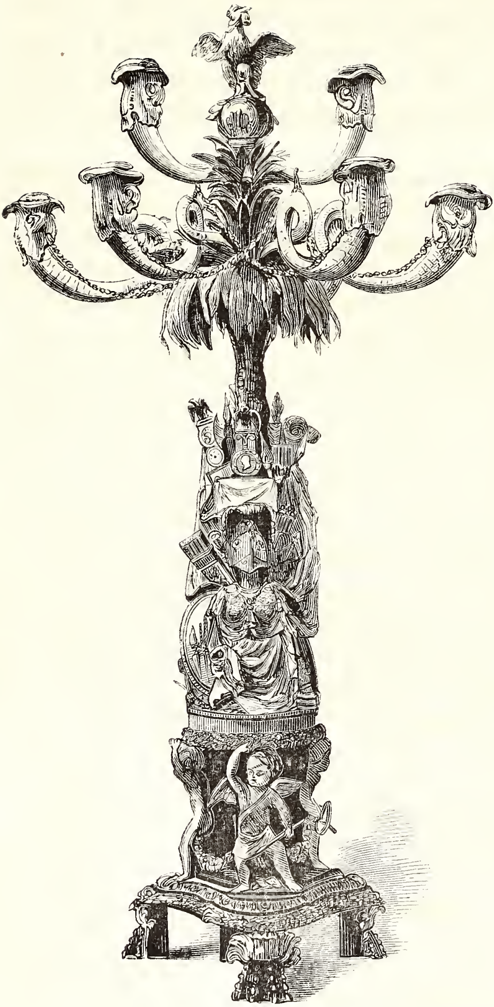
CLOCK (BRONZE, GILT.)

p. 102.



CANDELABRA (BRONZE GILT.)

p. 102.



CANDELABRUM, (BRONZE GILT). p. 103.

design of the candelabrum on each side is composed in part of the same ornaments, and the connection is kept up by the figures, the one a Moor and the other a Crusader, with just sufficient play of the imagination to prevent a stiff and formal repetition of any one part of the design. The prominent parts are finished with gilt, or are silvered, which adds materially to the richness and effect of the whole.

Works of this description are now produced at prices which are insignificant when compared with the expense attending like productions of an earlier period, and there is no surer way of increasing a love for the beautiful than by placing articles possessing this quality in the highest degree, within the reach of all. The mind of the uncultivated may not always discern the difference between the good and the bad, but long familiarity with the former will in time lead the least discerning to see that the repose and appropriateness of one design, not only gives satisfaction, but also increases the pleasure derived from a study of it; while that of another, marked by excess and incongruity (it matters not how florid or showy it may be) in the same ratio fails to command attention, and finally it will be set aside as unworthy of respect.

We cannot illustrate this better than by giving a cut of another bronze and gilt candelabrum, also of French workmanship. It will be at once seen that while it lacks repose, there is nothing definite about the design, or any thing to arrest and hold the attention. A closer examination will show marked defects. The pedestal is surmounted by cupids and a wreath of flowers. Above these rises a palm tree, probably; at any rate, a tree of some kind, with a straight shaft and a spreading top. Around the trunk of the tree, and extending nearly to the branches, trophies of arms, shields, spears, battle-axes, &c., are gathered, and so arranged as to make a gradually diminishing line from the base to the top. From the leaves dolphins start out, their tails buried amid the foliage, and their bodies so twisted that their backs are turned down, and their open mouths turned up to receive the candles they are placed there to hold. In the centre of all these the top of the tree expands into the form of a globe, on which the cock of France, with extended wings, and crowing lustily, is perched—

the whole being an absurd collection of parts that have not, nor can have by any possibility, the least connection. Trees do not usually expand into the form of a globe, nor are they frequently resorted to by dolphins, and even if this accorded with the tastes of the latter, it is hardly possible that they would assume so unnatural a position. It is a question how far natural forms may be used for ornament, but even when treated conventionally, there is no rule that will sanction the placing of them in a position that directly violates the laws of nature.

And while we are on this subject we may here present one more candelabrum (one of American workmanship), which is also of bronze gilt. We believe that we have already mentioned that twenty years ago every article of this description used in the United States was imported, but now we are able to produce elaborate designs, many of which show a marked improvement, and are greatly superior to patterns that were once deemed worthy of attention. But the design before us (and we give it merely as an illustration of our subject) is loaded down with an excess of ornament, the designer having left no spot on which the eye can rest, or where it can seek for a moment's repose, before it is forced to trace out the remainder of the elaborate pattern. From top to bottom there is the same excess, and this too often marks the best ornamental works produced in this country. Such was particularly the case with many articles displayed at the exposition of the Crystal Palace in New York, and some of the defects in this way, of articles there exhibited, may yet receive our attention.

As high a value should be set on the unadorned parts of the surface as on those enriched with ornament, for the value of the latter is increased by its contrast with the former. A well received rule requires that there should be as much of the one as of the other, and all excess marks a want of taste. If this be correct, then the candelabrum should be condemned, for the impression it conveys is not only confusing, but we also feel that the design was intended to show off the ornaments, and not the ornaments to enhance the value or improve the outline of the design, to which they should be subordinate.

CANDELABRUM, (BRONZE GILT). p. 104.

An article may be elaborately ornamented and not infringe any rule here given. As an illustration of this we give a French vase of exquisite workmanship. At a glance we take in the whole design, and without having to pause for a moment to decipher any portion of it. The outline is clearly defined, and it embraces a due proportion of straight, angular, and curved lines. The ornaments are rendered subordinate to the whole, and each and every part can be examined in detail, while the whole combines to produce a general effect. Ornaments, to be beautiful, must be appropriate. It is in vain that the workman elaborates his design, if it be not based on right principles. Two wrongs do not make one right, and as a display of jewels, intended to heighten the attractions of one in years, but serves to show the marks of time on the brow that once needed no aids to command attention, so the rococo adornments, which are but too prevalent in our ornamental art, only render more conspicuous the defects they are intended to screen.

We naturally crave that on which time and labor have been expended, to render it more beautiful and increase its attractions. This is inherent in the human race. Venice derived untold wealth from her trade in glass jewelry with the savage hordes of Africa and Asia. The Peruvians freely gave their treasures of gold for gew-gaws wherewith to deck their swarthy forms. It is this same feeling—more refined and elevated, but no less the same—which governs the selections of civilized nations. The highly cultivated Greeks were satisfied only with the most exquisite forms in their ornamental art. The Romans were less refined and less fastidious, and finally the higher standard was lost until the revival known as the Renaissance, when a pure taste was once more inculcated. Then domestic articles of every description were conceived in such fine forms, and were enriched with such exquisite ornaments and graceful little figures, as to render them eagerly sought after as true specimens of art. Many of these designs are now reproduced with fidelity, and the manner in which they are received is an evidence of the high appreciation of their beauty. We here introduce two specimens that are distinguished for beauty of outline and elaborate finish. They are

in bronze, of French workmanship, and are copied from the works of Benvenuto Cellini. They are rich without excess, and while they display an exuberance of fancy, it is governed by principles that allow not the ornaments employed to interfere with the general plan; rather are they introduced as a part of the whole, and not one of them could be spared without injury to the general effect.

Although attention has of late years been called more particularly to the employment of bronze for ornamental and useful purposes, it has by no means reached the point at which all its fine qualities are discerned, and it is only when we meet with works like the above, from the antique, or such castings as the wounded heron, and the boar's head, already referred to, that we see how readily it may be adapted to works of the most elaborate and difficult character. And for articles of daily, use there is nothing within our reach that offers so many advantages. It can be worked at a moderate expense, any little ornaments introduced are brought out clear and sharp, and a variety of different shades may readily be given to the several parts.

As an example of its adaptation to simple articles of domestic use, we here introduce an inkstand. The group which adorns the top represents the triumph of Amphitrite, and the whole is beautiful and attractive. Paper weights, lamp stands, candlesticks, brackets, and a thousand and one articles of daily use may be made of it. And if real taste be displayed in the design, the interest in the article will be lasting, and no change of fashion can affect its value. The spirit of the workman must pervade the work, which, to be successful, must address itself to the mind as well as to the eye. The hand that formed it may have been unsteady, and the exquisite finish, that by many is deemed essential, may be lacking; but if it be wrought with a true and abiding love, it will have a charm that the most careful manipulation alone could never impart to it.

The French have ever deemed this culture essential, and one, familiar with their tastes and pursuits, says that when they enter a restaurant to dine they want a feast spread for their eyes, for their sense of beauty, as well as for their palate; and this love of

CELLINI VASES, BRONZE.

p. 106.

the refined and beautiful in all such places of public resort has led another to say, "If one could feed with one's eyes, the meal would be a banquet," and here we have the effect and the result of their lavish decoration embraced in a few words. "Mark how much is done in this cheap café for the eye, and how well it is done. The architect has accommodated his plans to the awkward shape of the ground so ingeniously, and gilders, and carvers, and painters, have so come to his aid, that I am not sure but the general aspect of the room is finer than that of Taylor's splendid rectangular saloon on Broadway. The very iconographic commercial advertisements, that decorate rather than disfigure the lower part of the side walls, have some touch of art in them. And so, while these Parisians, artists, or artisans, are sipping their coffee, they are receiving constantly through their eyes, an unconscious culture of their taste, for which they are distinguished throughout the world."

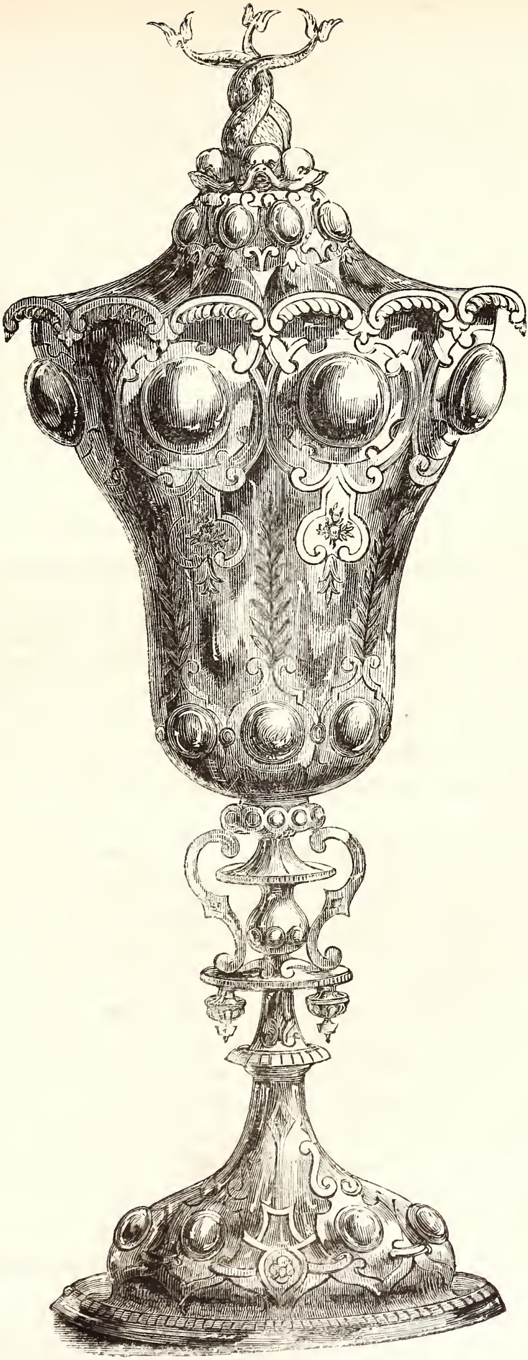
But this was not always so, and in the time of Louis XIV. neither music nor painting seemed to form a part of the education of even those who had the leisure to devote to these elevating studies. Then the cinque cento, which is the purest form of the Renaissance, and which had pervaded all manufactures of the time, was found too exacting in its rules, and a new style, the Louis Quatorze, commenced to develope itself. This found expression wholly in gilt stucco work, to the almost exclusion of other styles of decoration, and, finally, after becoming fully elaborated in the Louis Quinze style, ultimately was debased in the Rococo, in which all symmetry was avoided, and the designers aimed only at extravagant effects.

CHAPTER VII.

GOLD AND SILVER.

THE first notice that we have of the precious metals is in the form of money, passed by weight, and then for the purposes of personal adornment. At a later period, gold also entered largely into the fabrication of articles to which steel alone is now applied, and during the middle ages the munificence of the church stimulated the goldsmiths to undertake the most exquisite works in the precious metals. At that period gold and silver were not so abundant, and the goldsmiths worked equally on copper and other metals.

When Charlemagne wished to restore the cultivation of the arts in the vast empire he had subjected to his sway, he found, in the goldsmith's department, artists ready to carry out his views. The churches were abundantly provided with vessels of gold and silver; while princes and bishops rivalled each other in the magnificence of their gifts to the basilicas, restored and embellished by the orders of the powerful emperor. Charlemagne's will is a curious evidence of the immense riches possessed by this prince in works of the goldsmith's art. Among other objects, he had three tables of silver and one of gold, of considerable size and weight. On the first was traced the plan of the city of Constantinople, upon the second a view of Rome; the third, very superior to the others in the beauty of its workmanship, was convex, and composed of three zones containing a description of the



SILVER VASE, OF ELIZABETHAN PERIOD.　　|. 108.

whole universe, figured with skill and delicacy. Thus science and art had united their efforts in the execution of these monuments.

A considerable number of the finest specimens of the goldsmith's art possessed by Charlemagne followed him to the tomb. It it said that his body was embalmed and enclosed in a sepulchral chamber, under the dome of the church of Aix-la-Chapelle. He was seated upon a throne of gold, and clothed in his imperial robes; at his side was a sword of which the pommel, as well as the decorations of the scabbard, were of gold; his head was ornamented with a chain of gold, in which was enshrined a piece of the true cross. Before him were suspended his sceptre and his buckler, both also of gold.

These riches attracted the cupidity of the succeeding Emperors of Germany, who took possession of them; probably the spoliation occurred when, in 1166, Frederick Barbarossa distributed his bones to be enclosed in shrines and reliquaries as those of saints. The only specimens of goldsmith's work belonging to that great man, are his crown and sword.

In Italy the great dignitaries of the church followed the examples set them by the popes, and the magnificent altar of gold of the church of St. Ambrose at Milan, which has passed uninjured through ten centuries, notwithstanding its immense value, gives a high idea of the importance of the goldsmith's art at the beginning of the ninth century.

But it was not Italy alone that distinguished herself in the ninth century by the magnificent productions of her workers in gold. France had preserved the artistic processes transmitted to her by St. Eloy, who rose from a simple artisan to be the most remarkable man of his century, and whose virtues were rewarded by canonization.

The works of the Western goldsmiths could bear no comparison, however, with those of the Eastern empire, and it cannot be doubted that the goldsmith's art was maintained at Constantinople in a very flourishing state throughout the tenth century. The tenth century was, for the West, an age of iron; calamities of every kind overwhelmed Italy especially; and it cannot be

wondered at, that, amidst incessant troubles and devastating wars, the leading workers of the ninth century should have no successors in the tenth. The eleventh century was a period of renovation; the principles of ancient art had fallen completely into oblivion; and the goldsmith's, which had already departed from them in some of its productions, followed the steps of the other arts. It was necessary for the service of the temples which arose on every side in a new style, that there should be provided appropriate plate, and the goldsmiths were called upon to invent other forms for ecclesiastical vessels, and for shrines to contain the relics of the saints; the same enthusiasm which led princes, communities, and people to demolish the old churches for the sake of building new ones, leading them also to refashion the utensils, and consequently to melt down almost all the pieces of goldsmith's work.

The forms then adopted for the different church utensils received the stamp of a severe style, pre-eminently ecclesiastical. Throughout the middle ages they preserved this character, which was again altered, decidedly for the worse, by the re-introduction of Græco-Roman forms.

The goldsmith of that day was required to know how to grave his metals with burins and scalpers, to execute bas-reliefs and figures in repoussé work, and afterwards to chase them: it was expected of him to compose the "nigellum," for filling the incisures of his fine engravings, and to make the cloisonné enamels, with designs in gold, mixed alternately with gems and pearls in the ornamentation of sacred vessels: nay, further, it was necessary that he should be a skilful modeller in wax, and know how to cast figures in full relief, intended for the decoration of his pieces, and the handles in the form of dragons, birds, or foliage, which he would adapt to his vases.

The political division of Italy into a number of petty sovereignties, and the liberty enjoyed by many of the great towns, were eminently favorable to the development of the art of luxury. The princes, the great dignitaries of the church, the rich and noble merchants of Florence, Venice, and Genoa, the opulent towns, all vied with each other in magnificence. The armor of

the captains, the plate of the princes and nobles, the jewels of the ladies, the sacred vessels, and the decorations of the altars, all furnished incessant occupation for the goldsmiths, so, that notwithstanding the intestine and foreign wars which almost constantly desolated Italy, until towards the middle of the sixteenth century, the art was held in higher esteem in that country than in any other in Europe.

Nuremberg and Augsburg became, in the sixteenth century, the principal centres of the goldsmith's art in Germany. At a later period, Dresden, Frankfort-on-the-Maine, and Cologne, alike produced skilful goldsmiths. The goldsmiths of Nuremberg preserved in their productions, longer than those of Augsburg, a certain feeling of German art; but in the second half of the sixteenth century, the productions of the German goldsmiths are so confounded with those of the artists of Italy, in every thing relating to the execution of figures, bas-reliefs, and ornaments, that it would be very difficult to distinguish the one from the other, were it not for the form of the vases, which almost always preserved a stamp of originality. Moreover, nothing can be more graceful than the arabesques which enrich the German metal-work of that period, nothing more exquisite than the little twisted figures that form the handles. The artists of Nuremberg were distinguished for the elegance and richness of their works, and while they studied the beautiful for themselves, and wrought out in precious metals their own ideas, they were not indifferent to the beauties that adorned the works of other nations, but freely adopted whatever tended to increase their knowledge, or give an additional value to their productions.

During the first part of the eighteenth century, the productions of the goldsmiths still preserved, in France and Germany, the character of the style of the sixteenth. Under Louis XIV., in the goldsmith's, as in the other arts, the delicate style of the Italian Renaissance was abandoned for larger and heavier forms. In 1688, when France was compelled to contend against almost all Europe, recourse was had to every kind of expedient, in order to meet the expenses of the war. The nobility were ordered to bring all the pieces of massive silver they possessed, to the Mint.

The king set the example; he caused to be melted down, those tables of silver, those candelabra, and those large seats of massive silver, enriched with figures, bas-reliefs, and fine chasings, the works of Balin, one of the most skilful goldsmiths of the time. They had cost ten millions, and produced three.

Purity of style was quite forgotten in the eighteenth century; affectation and singularity alone were admired. Dinglinger, who settled at Dresden, in 1702, and from that period worked almost solely for the Elector of Saxony, was completely enslaved by the vitiated taste of his period. He excelled, particularly, in chasing small figures, which he colored in enamel. The Green Vaults of Dresden contain his finest works. The most curious of all, is the representation, in little detached figures, of about from two to two and a half inches high, of the Court of Aurengzebe at Delhi. The Great Mogul is seated upon a magnificent throne, surrounded by his great officers of state. Princes, his vassals, are kneeling before the steps of his throne, and presenting him with rich offerings, which the officers of the household are eagerly receiving. In the foreground are courtiers and ambassadors from Asiatic provinces, attended by a pompous train, to pay their court to the monarch, bringing with them valuable presents, among which may be noticed elephants, with trappings prepared for war, horses richly caparisoned, camels, and dogs. All these numerous little figures, chased in gold, and enamelled in colors, have been made separately, and the greater number are removable at pleasure. They are distributed over a plateau of silver, upon which the artist has represented three courts of the palace of Aurengzebe. The court in the background, covered with a carpet of cloth of gold, is surrounded with porticoes and small buildings, in the midst of which is the rich tent which covers the throne of Aurengzebe. Dinglinger executed this work from drawings, brought from India, and from the narratives of travellers who had visited the court of that prince: nothing, therefore, can be more correct than the costumes.

The Asiatic ceremonial and etiquette are also strictly attended to. Dinglinger's little figures are chased with extraordinary perfection; they have life, movement, and a highly characteristic

expression. He was occupied, it is said, eight years at this work, assisted by his sons and two brothers, one of whom, George Frederick, was a celebrated painter upon enamel, and he also employed fourteen workmen. The Elector paid him fifty-eight thousand four hundred and eighty-four crowns of Saxony for this piece.

Gold exceeds all other metals in ductility and malleability. It may be beaten into leaves one-two hundred and eighty thousandth of an inch in thickness, and a wire of only seventy-eight one-thousandths of an inch in diameter, will sustain a weight of one hundred and fifty pounds. Its melting point is about 2590° Fahrenheit's scale. It is perfectly unchanged by fire with access to air, and the intense heat of a glass-house furnace has no other effect upon it than to keep it in fusion. It is not acted upon by any solvent except a mixture of muriatic and nitric acids, or aqua regia, which is formed by dissolving sal-ammoniac in nitric acid; but it yields, like all substances, to the solar rays collected and concentrated by the burning-glass, not only rising in vapor, but becoming covered with a violet-colored vitreous oxide. When in extremely thin leaves, gold is, to a certain degree, transparent, and on being held between the observer and the light, appears of a beautiful green color. When large quantities of gold have been fused, and then slowly allowed to cool, cubes, more or less modified on their edges and angles, are frequently obtained. Native gold also affords numerous well-defined crystals belonging to the cubic system. If the charge of a powerful electric battery be passed through an exceedingly fine gold wire, it becomes entirely dissipated; and when a sheet of white paper is held beneath it at the time of the discharge, it becomes stained with a purple line, caused by a deposit of minutely divided metallic gold. If, instead of white paper, a plate of polished silver be employed, it is traversed by a brightly gilded line, which is firmly attached to its surface. A globule of gold, when exposed between two charcoal electrodes to the action of a powerful voltaic battery, enters, almost immediately, into fusion, and gives off abundant metallic fumes, by which its weight is rapidly diminished.

When precipitated from its solutions, gold assumes a dark

brown color, but on being rubbed by a piece of polished steel, or other hard body, readily assumes its ordinary color and metallic aspect. If precipitated gold, in this form, be heated to whiteness, and when in that state struck repeatedly with a heavy hammer, its particles readily become welded and united into a solid mass, without their having undergone actual fusion.

To distinguish gold, a simple experiment can be made by every one. Thus, if it be found that a specimen is readily scratched by silver, copper or iron, and scratches tin and lead, it may, if of the right color, and sinking rapidly in water, be fairly assumed to be gold.

Gold is not found mineralized, like other metals, but in what is termed the native state; as, however, the species exhibit some varieties of color, these have been made the basis of some subdivisions among mineralogists. Gold appears under a great diversity of circumstances, both as to the substance with which it is intermixed, and the appearance which it presents; for instance, it is found massive, disseminated in particles, in films and strings, and also crystallized in diverse forms, single and in groups. When deposited in rocks or veins, it mingles with several of the earthy fossils, and with many metalliferous masses, as iron and copper pyrites, vitreous ores, &c., and besides its occurrence in solid bodies, considerable quantities have always been found in alluvial situations, and in the beds of rivers, where it probably first attracted the attention of mankind.

The simplest method of obtaining gold, consists in collecting the grains or small particles from the beds of rivers, especially after rains, which bring down fresh matter from the mountains. In some locations, skins of animals are laid in the water course, to catch and retain the metallic particles. It has been supposed that the fable of the golden fleece, so well known in classic mythology, has reference to this practice. The Indians of Brazil, when it was first ascertained by Europeans that gold abounded in that country, were in the habit of using fish-hooks of gold, of their own make, and the excitement that followed the discovery, was not unlike that in our own country, over the deposits of gold brought to light in California.

SILVER VINE VASE, LINED WITH RUBY GLASS. p. 115.

The dusts and grains of gold are smelted, in Brazil, with a flux of muriate of mercury; the furnaces are heated with charcoal, and the contents of the crucible are poured into iron ingot moulds, holding about thirty-two pounds of the metal. Very pure gold runs in about three hours, but when it contains more foreign admixture, it is proportionately refractory in the furnace, and requires more of the flux.

The process of gold-assaying among the native miners of South America is very simple. A fragment of quartz is pounded and rubbed to a powder, between two pieces of granite. A bullock's horn, of black color, is the only assay instrument. It is cut longitudinally into two equal pieces, partly on the curve, so that one half forms a kind of spoon, the inside of which is polished. In the spoon the powder is placed; the water is poured in and shaken, and then poured off. A second and third water is applied; when nothing is left but the coarser particles at the bottom, and at one edge of them, conspicuous on the black ground, is seen a fringe of gold powder, if gold be present.

Gold is also purified by submitting it to the process of cupellation, parting, and quartation; by the former process the refiner removes every particle of lead or other inferior metallic alloys; and by the latter, separates any portion of silver which might remain intermixed with the gold after the first process. The cupel, in which the first operation is performed, and which is so called from its resemblance to a little cup, is composed of calcined bones, or, in some cases, with an intermixture of fern ashes. A vessel made of these materials, slightly moistened, and given the form of the cupel, by means of a mould, not only resists the action of the most vehement fire, but absorbs metallic bodies when changed by heat, into a fluid scoria, while it retains them so long as they remain in a metallic state.

In a small vessel of this description, placed within side a sort of bent, perforated tile, made of crucible earth, and surrounded with an intense charcoal fire, the gold, in little buttons, is subjected to the heat. As the heat is continued, and the process goes on, a various-colored skin, consisting of the scoria of the lead, or other metals present, rises to the top, which, liquefying, runs to

the side, and is there absorbed by the cupel. This operation is continued, until a sudden luminous appearance of the mass in fusion, shows that the last remaining portion of inferior alloy has been given out. As, however, the gold may yet retain some portion of silver, which, being nearly as difficult of oxidation as the more precious metal, is not thrown off in the cupel, the next process is called parting, which consists in reducing the metal to the state of very thin plates, by rolling; these, being cut into small pieces, are digested in hot diluted nitric acid, which dissolves the silver, leaving the gold in an undissolved, porous mass. This course is adequate to the attainment of the required degree of purity, when the amount of silver is so considerable, in proportion to the gold, as thoroughly to expose it to the action of the acid; but when the alloy of silver is very inconsiderable, another course is adopted, that of quartation, so called, because the mixture is composed of three parts of silver and one of gold, which, on being laminated and digested in the acid, exposes every portion of the gold to the effects of the separating menstrum. In some cases the two metals are melted together, and sulphur being thrown in, combines with the silver, the gold falling to the bottom.

Wolf proposes, in the "Practical Hand-Book of Jewellers," to fuse the brittle gold in a new crucible, and when melted, to throw in one or two pieces of sulphur, of the size of a pea, to shake the crucible a little with the tongs, and to cast it rapidly into a heated mould. He also proposes to render small pieces malleable by coating them with borax, and heating them in the blow-pipe flame until the surface commences fusion.

Both of these methods are resorted to at the United States Mint; but the choice of either depends upon the nature of the accompanying metals that give the gold its brittle character. When there is a quantity of iron present, the gold is fused with a mixture of sulphur, potash and soda, which will remove it by making the very fusible mixture of sulphurets of iron and alkali. If tin, arsenic, or antimony be present, a good flux is a mixture of borax, soda, and saltpetre, the last for oxidizing the foreign metals into their respective acids, the soda to give the base to

those acids, and the borax to collect the slag. In both these cases, a sand or clay crucible is preferable to a black lead pot, in which last the graphite acts reducingly. Where lead is present, this process may partially effect its removal; but it is more completely effected during quartation, and by washing the fine gold thoroughly with hot water, after extracting the silver with nitric acid. Another method of removing lead would be to fuse the gold with a little saltpetre, borax and silica, whereby a fusible slag of oxide of lead would result, and might be skimmed from the surface of the gold. Platinum and palladium, not unfrequently present in California gold, are also removed by the nitric acid, in parting silver from gold. Grains of iridosmin have been observed in California gold. To obtain this metal the gold is dissolved by nitro-muriatic acid, and the iridosmin obtained pure.

The methods of assay above described, although succeeding perfectly for the determination of the value of bullion and other unmanufactured products, cannot be conveniently applied to the examination of jewelry, which would be required to be destroyed, in order to ascertain its composition, and consequently a method is employed by which its standard is readily determined to within one per cent. of the truth, whilst the most delicate chased article is in no way disfigured by the trial. This process essentially consists in rubbing some convenient part of the object to be examined on a hard siliceous stone of a black color, on which it thus leaves distinct metallic traces; from the aspect of these marks, and their behavior when treated with nitric acid or a weak solution of aqua regia, the assayer judges of the gold subjected to examination. The material employed for this purpose, and which is generally known by the name of *touchstone*, is a coarse-grained species of quartz, colored by bituminous matter, and which was anciently brought for the purpose from Lydia, although stones of equally good quality are now obtained in Saxony, Bohemia, and numerous other localities.

In order to be enabled to judge of the value of an alloy from the nature of the mark left by it on the surface of the stone, the assayer is furnished with a series of small bars, or touch-needles,

formed of alloys of copper and gold, of which the composition is accurately determined.

The trace left on the stone by the alloy to be examined, is successively compared, both before and after the action of an acid, with the different marks obtained from these needles, and it is supposed to possess a similar composition to the needle whose mark agrees most closely with it under both these circumstances. In making these assays, the first streak obtained on the stone cannot be employed to ascertain the composition of the object examined, as the surface of jewelry is invariably rendered, by the process of coloring, of a higher standard than that of the alloy of which it is throughout composed. For this reason, therefore, the object must be passed once or twice over the surface of the stone, in order to remove the superficial coating of richer alloy, before making the streak from the comparison of which with those of the needles the commercial value of the mixture is to be determined. This method, although affording much less accurate results than those obtained by inquartation, is nevertheless for many purposes sufficiently exact.

Gold and silver are seldom employed for the purposes of the arts in a pure state, but are alloyed; the gold with a small quantity of silver or copper, and the silver with a small quantity of copper, by which their hardness and fusibility are considerably increased.

In this country the standard of the alloy of gold is calculated in fractions of unity expressed in carats. A carat is an imaginary weight, or rather, ratio. Any piece of gold is supposed to weigh twenty-four carats, and its fineness is expressed by the number of carats of fine gold. In this way a gold coin is said to have a standard of twenty-two carats, or, in other words, it consists of an alloy in which in every twenty-four parts there are twenty-two parts of fine gold and two of alloy. The fine gold of the jeweller is as nearly pure as it can be wrought, but ordinary jeweller's gold is much alloyed.

The coloring, as it is called, of jewelry, is effected by externally dissolving out the copper with which it is alloyed, and thereby exposing a superficial facing of fine gold. To produce

SILVER TEA SERVICE OF AMERICAN MANUFACTURE. p. 118.

this effect, the object to be colored is first heated nearly to redness in a gas jet or spirit lamp, and then plunged into a weak solution of nitric acid, by which the copper on its surface is removed. The same effect is also produced by placing for a few minutes the object to be colored in a paste composed of a mixture of alum, common salt, and saltpetre. In this case the chlorine evolved from the mixture dissolves out the copper, and leaves the object with a surface which is readily brightened by polishing, and, when finished, possesses all the depth of color possessed by pure gold.

The gilding of metallic ornaments is either performed by rubbing their surfaces, rendered perfectly clean by immersion in dilute nitric or sulphuric acid, with an amalgam of gold and mercury, and then expelling the latter metal by heat, and subsequently burnishing down the deposited gold; or, when the object to be gilt is entirely composed of copper, it may be made to receive a covering of gold by being first cleaned and amalgamated by being dipped into a solution of nitrate of mercury, and then, after being carefully washed, placed in a vessel containing a boiling solution of chloride of gold in an alkaline carbonate. The objects gilt by this method are afterwards colored by dipping them into water containing a mixture of nitre, sulphate of zinc, and green vitriol; they are then dried at a charcoal fire, and subsequently washed in clean water. These, and all the other processes by which gilding was formerly effected, have, however, within a few years, become in a great measure superseded by the various processes of electro-gilding, which is described in another chapter, and which consists in depositing from its solutions, by electric agency, a layer of gold of any desired thickness.

The solution most commonly employed for this purpose is cyanide of potassium, containing cyanide of gold; the subject to be gilt is attached by a metallic wire to the negative pole of the arrangement, whilst in connection with the positive is a piece of pure gold, which is dissolved in proportion as the metal is deposited on the object to be gilt. By this means, therefore, the thickness of the coating is not only entirely under the command of the operator, but the strength of the solution is also constantly kept

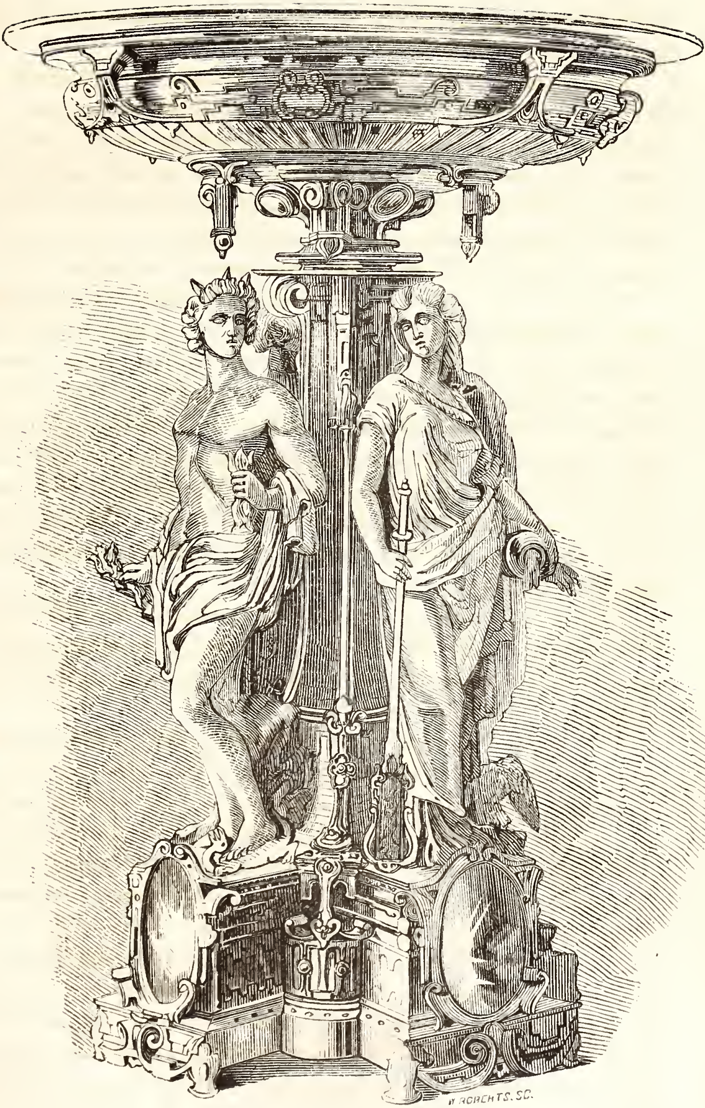
up at the expense of the ingot of gold in communication with the positive pole.

The making of gold plate differs scarcely at all from the manufacture of wares of silver. Vessels of gold, on account of the intrinsic value of the materials, are generally fabricated from the most costly models, a circumstance which greatly enhances their value, so that repetitions of the same patterns from steel dies, as practised almost universally in the working of silver, are by no means common, especially when the pieces are large.

Formerly, by the term goldsmith was understood an individual of a class more nearly resembling the banker than the plate-worker of the present day; as it was through their hands that the sovereigns of Europe and their opulent subjects transacted pecuniary business with one another; and, as, during the middle ages especially, sovereigns and great men were almost the only classes of society in Europe who could indulge in the luxury of golden ornaments, the few artists who were employed in ministering to the taste were persons of importance, and generally eminent sculptors.

Plate is not accounted gold or silver unless of standard purity, which is ascertained by scraping off a small portion, and by various tests; if found pure it is stamped by assay officers, and its integrity is admitted accordingly.

The terms "molten" and "beaten" gold, used by writers of antiquity to denote such works as were executed by the process of casting or hammering respectively, are still applied occasionally. Articles are very rarely, however, cast in gold, owing to the great shrinking which takes place on the cooling of the metal in the mould, in consequence of which it is difficult to obtain that sharpness of impression, so conspicuous in many figures copied from models by this method in other metals. Although to the use of the hammer the gold plate is in general indebted for the form it assumes, and the perfection of all the details of beauty, the labor of the artist has been much abridged by the modern invention of steel rollers, by means of which the ingot is reduced into sheets of whatever thickness or size the work may require. This method of laminating the metal is of great importance in the



SILVER CENTER PIECE OF AMERICAN MANUFACTURE. p. 120.

making of large articles, where, otherwise, the cost of workmanship would be greatly enhanced.

Repoussé work may be traced to a period of remote antiquity. The metallic objects which Homer describes are always worked with the hammer, and doubtless the colossal statues of the ancients were made in this way. Whatever degree of lightness may be obtained for cast metal, by means of the perfection of the mould, it can never be compared with that of a sheet of metal reduced by the hammer to the utmost thinness of which its malleability would admit. The repoussé process was principally used in the making of ornamental armor, and likewise in the goldsmith's art, which, up to the eighteenth century, comprised the execution of bas-reliefs and statues of gold and silver. In tilting armor, the object being to combine richness with lightness, and the work of the goldsmith to produce pieces of large dimensions of the least possible weight, nothing better could have been devised than repoussé work.

During the whole of the middle ages, bas-reliefs, statues, and vessels of gold and silver, were almost all worked in repoussé, and afterwards chased, and Benvenuto informs us in his treatise on the goldsmith's art, that this process was alone in use among the goldsmiths of his time in France and Italy; that he himself employed no other in the making of jewels, vases, and small figures of gold and silver, and it was only the handles of vases and other pieces, which are made separately, that he executed by casting.

A process of ornamenting, much in vogue in the fourteenth century, consists in marking the design by a series of dots, the lights and shades of which made the figure conspicuous, and gave a most agreeable effect.

The preparation of gold leaf, as now carried on, is as follows. The metal is first reduced into long, thin strips, by means of steel rollers. It is then cut into little pieces, which are beaten on an anvil, and afterwards annealed. One hundred and fifty of these pieces, an inch square, are laid two together between leaves of vellum, about four times that size, and laid twenty thicknesses on the outside, the whole being enclosed in a parchment envelope. In this state the mass is beaten with a heavy hammer, on a smooth

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marble block, till the gold is extended out to the size of the vellum, after which the whole is taken out, and the pieces cut into four with a knife. The six hundred pieces, thus produced, are interlaid, as before, with pieces of ox-gut, prepared in a peculiar manner, and called gold-beaters' skin. The beating is now repeated with a light hammer, until the leaves have reached the extent of the skin, that is, four inches square. The whole is then divided into four parcels, interlaid with membranes, and beaten until they are extended for the third time. After the last operation the gold leaves are placed upon a leather cushion, cut into the proper sizes, and placed between the leaves of a book, the paper having previously been rubbed with bole, to prevent adhesion. Two ounces and two pennyweights of gold, in the hands of a skilful workman, will make two thousand leaves, or eighty books, together with one ounce and six pennyweights of waste cuttings, hence, the contents of one book weighs 4-8 grains, and as the leaves are 3-3 inches, the thickness of a leaf is one 282,000 part of an inch.

The art of gilding consists in covering bodies with a thin coat of gold; which may be done either by mechanical or chemical means. The mechanical mode is the application of gold-leaf or gold powder to various surfaces, and their fixation by various means. Thus, gold may be applied to wood, plaster, pasteboard, leather, and to metals, such as silver, copper, iron, tin, and bronze, so that gilding, generally speaking, includes several arts, exercised by very different classes of workmen. In all these cases the gold is applied and secured by the aid of a particular kind of cement, or gold size; and this cement differs in character, according as the gold is or is not to be burnished with a smooth piece of agate or flint.

The ordinary mode of gilding is very simple, and requires only delicacy on the part of the workman to produce the desired effect. This is done by laying gold-leaf upon a design which has been previously drawn with a pencil dipped in color mixed with size, and when completed, it is called dead gilding. There are two ways of producing bright or burnished gilding, and the first process is the same in both. A weak solution of isinglass is laid

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SILVER WINE COOLER, LINED WITH RUBY GLASS. p. 122

upon the article, the size of the intended ornament, upon which gold-leaf, of the cleanest kind, is laid smoothly. When dry, the design is pencilled on with copal varnish, and the superfluous gold is wiped off with cotton wool dipped in water. The other method is to put in the design with asphaltum. When dry, the gold-leaf not covered is rubbed off with cotton wool. The asphaltum is wiped off the gold with cotton wool and turpentine, which leaves the ornament in bright gold, the gold having been laid upon a bright surface. The gold in both cases is fixed with copal varnish, and the advantage of the latter plan is, it enables the workman to see what he is doing, and thus give more freedom and a higher finish to his work. Designs are sometimes covered with powdered bronze, instead of gold, when they are pencilled with the size.

Gold lace is not gold lace. It does not deserve this title, for the gold is applied as a surface to silver. It is not even silver lace, for the silver is applied to a foundation of silk. Therefore, when we admire the glittering splendor of gold lace, we should, if "honor be given where honor is due," remember that it is silk lace with a silver-gilt coating. The silken threads for making this material are wound round with gold wire, so thickly as to conceal the silk; and the making of this gold wire is one of the most singular mechanical operations imaginable. In the first place, the refiner prepares a solid rod of silver, about an inch in thickness; he heats this rod, applies upon the surface a coating of gold-leaf, burnishes this down, applies another coating, burnishes this down, and so on, until the gold is about one-hundredth part the thickness of the silver. Then the rod is subjected to a train of processes, which brings it down to the state of a fine wire; it is passed through holes in a steel plate, lessening, step by step, its diameter. The gold never deserts the silver, but adheres closely to it, and shares all its mutations; it was one-hundredth part of the thickness of the silver at the beginning, and it maintains the same ratio to the end.

As to the thinness to which the gold-coated rod of silver can be brought, the limit depends on the delicacy of human skill; but the most wonderful example ever known, was brought forward

by the late Dr. Wollaston, a man of extraordinary tact in minute experiments. This is an example of a solid gold wire, without any silver. He procured a small rod of silver, bored a hole through it from end to end, and inserted in this hole the smallest gold wire he could procure; he subjected the silver to the usual wire-drawing process, until he had brought it to the finest attainable state; it was, in fact, a silver wire as fine as a hair, with the gold wire in the centre. How to isolate the gold wire was the next point; he subjected it to warm nitrous acid, by which the silver was dissolved, leaving a gold wire one-thirty-thousandth of an inch in thickness, perhaps the thinnest round wire that the hand of man has yet produced. But this wire, though beyond all comparison finer than any employed in manufactures, does not approach in thinness the film of gold on the surface of the silver in gold lace. It has been calculated that the gold on the very finest silver wire for gold lace, is not more than one-third of one-millionth of an inch in thickness; that is, not above one-tenth the thickness of ordinary leaf-gold! The mind gets not a little bewildered by these fractions; but we shall appreciate the matter in the following way: Let us imagine that a sovereign could be rolled or beaten into the form of a ribbon, an inch in width, and as thin as this film, then this ribbon might form a girdle completely round the London Crystal Palace, with, perhaps, a little to spare.

Gold wire drawing in India is performed by hand, and proves to be a long and tedious process, which only age and experience can master. A bar of silver is first prepared by roughing the sides with a file, and when this is done it is covered with gold-leaf, to the proportion of one twenty-third part of the whole metal. It is then subjected to a strong heat, and when taken out it is hammered, and rubbed with a piece of wood, preparatory to the drawing process. This is effected in a rough apparatus, pierced with holes of various sizes, which are fitted with pincer jaws to grasp and retain a hold on the metal sufficiently strong to draw it through when the cylinder is turned by the operator. In this way the wire, which is repeatedly coated with wax, to overcome the friction, is gradually reduced. But occasionally it is again fired and annealed, to prevent its breaking in the process,

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as without such treatment it would be too brittle to work beyond a certain point.

Other workmen, of more delicate hands, now take the wire and draw it through steel plates, reducing it in size by degrees, until it is not larger than the finest hair. But it is still unfit for weaving, and to prepare it for this purpose a number of threads are drawn over an anvil polished higher than the surface of glass, where they are subjected to the blows of a hammer, equally polished, in the hands of a workman who would spoil the whole if not exceedingly expert. Each blow is sufficient to flatten all the wires so far as they are covered by the surface of the hammer, and these blows are continued till the whole lengths are equally flat. Then they are wound on reels and placed in the hands of other workmen, to wind round a thread of silk, so as to appear as a thread of gold. This, it must appear, is a nice and delicate task, but one that the natives perform by hand with marvellous skill, as all their textures embroidered with gold thread will attest. But the wire that the Hindoo can only run out to the extent of one thousand or twelve hundred yards, in London, by means of proper machinery, can be carried to two thousand or twenty-two hundred yards.

The Aztecs, in their rude attempts at figure drawing, picture their workers in gold, who exactly resemble the same class of artificers of various Asiatic and African nations, many of whom understand the use of the blow-pipe, and those of Central America were exceedingly skilful in soldering, annealing, and chasing the precious metals with which they were bountifully supplied. But few of these relics have come down to us, however, for the intrinsic value of the statues and vessels of gold and silver that fell into the hands of the conquerors, caused them to be consigned to the melting pots of Europe, to be converted into coin.

CHAPTER VIII.

GOLD AND SILVER.

SILVER in ore, or other of the various forms under which it occurs, is much more widely disseminated than gold. It differs, too, from the latter metal in what may be called its geographical habitat. It has been remarked that warmer regions of the globe afford the greatest quantity of gold, but the richest repositories of silver are situated either in high latitudes or in elevated regions. The most celebrated mines in Sweden and Norway are at no great distance from the polar regions, and those which are in warmer latitudes are always situated near the summit of alpine mountains, commonly covered with snow. Africa produces abundance of gold, but is scarcely known to contain silver mines.

The most productive silver mines in the world are those of South America, New Spain, Peru, Mexico, and Potosi. According to Humboldt, the greater part of the metal extracted by mining in Peru, is found in a species of ore locally called pacos, of an earthy appearance; it is a brown oxide of iron, with silver disseminated through its mass in exceedingly minute particles. The ore of Chili is similar, and one vein has been mentioned as existing in the Andes, which has been traced for ninety miles, and is supposed to extend three hundred miles.

The Indians smelt the precious ores in a very simple and inartificial manner, but since the introduction of European settlers into the New World, the mining operations have been carried on with order and skill.

VICTORIA SALVER—(OXYDIZED SILVER) p. 126

Silver is extracted from its ores, properly so called, either by smelting in a manner similar to that practised with reference to other metals, or by amalgamation, the former being technically designated the "dry" and the latter the "wet" method. The ore in the latter process is reduced to an impalpable powder. It is then submitted to the action of mercury, which is the actual process of amalgamation. This amalgam is subjected to the action of heat, in a distilling furnace, by which the mercury is sublimed and the silver remains. The silver is then collected and melted in a crucible, but as it contains a portion of other metals that were combined with it in the ore, it is afterwards refined in a cupel or testing furnace.

The method of extracting silver from lead is every where similar in principle; it is very simple, depending upon the different essential properties of the two metals. Lead, when melted in the open air, loses its metallic appearance, and burns away into a kind of earth; but silver will not burn thus when exposed to the air in a fluid state. Hence, when a mass of lead and silver is melted in the open air, the lead will be burned to ashes, or into hard masses of a scaly texture, known as litharge, or silver stone, while the silver will sink to the bottom of the vessel in which the mass has been melted. In practice, however, and when the operation is conducted on a large scale, the silver is extracted from the lead by oxidation of the latter metal in a reverberatory furnace, of a peculiar construction.

A shallow vessel, called a cupel, is filled with prepared fern leaves, rammed down, and a concavity cut out for the reception of the lead, with an opening in one side for the nozzle of the bellows, through which the air is forcibly driven during the process. When the fire is lighted, and the lead is in a state of fusion from the reverberation of the flame, the blast from the bellows is made to play forcibly on the surface, and in a short time a crust of oxide of lead, or litharge, is formed and driven off to the side of the cupel opposite to the mouth of the bellows, where a shallow side or apperture is made for it to pass over; another crust of litharge is formed and driven off, and this is repeated till nearly all the lead has been removed. The operation continues about forty

hours, when the complete separation of the lead is indicated by the appearance of a brilliant lustre on the convex surface of the melted mass in the cupel, which is occasioned by the removal of the last crust of litharge that covered the silver. But the silver thus extracted is not sufficiently pure; it is further refined in a cupel lined with bone ashes, as in the cupellation of gold, and exposed to the intense heat of a furnace, so that the lead which escaped oxidation by the first process, is converted into litharge and absorbed by the ashes of the cupel.

In malleability and ductility silver exceeds all metals but gold. It may be extended into leaves not exceeding one ten-thousandth of an inch in thickness, and drawn into wire finer than a human hair. Its fusion point, according to Daniell, is 1873° Fah's scale. When fused in open vessels, it absorbs oxygen in considerable quantities, sometimes amounting to twenty-two times the volume of the metal itself. On becoming solid, however, the whole of this gas is again expelled, and to this circumstance is probably, in some degree, owing the metallic vegetation which takes place on the surface of silver buttons, when suddenly cooled in the cupel. When silver is heated to redness in contact with porcelain or glass, the absorbed oxygen combines with the metal to form an oxide, which, uniting with the silicic acid of the substance with which it is in contact, gives rise to the formation of a yellow enamel. When heated very strongly in a blast furnace, this metal gives off sensible metallic vapors, and if exposed to the high temperature between two charcoal electrodes in connection with a powerful voltaic battery, is readily volatilized. By fusing a large quantity of silver, and afterwards allowing it to cool very gradually, cubic and octahedral crystals may, on piercing the solidified crust, and running off the still liquid metal, be obtained. When solutions of silver are decomposed by the action of feeble electric currents, the precipitated metal is frequently found to assume a crystalline form. This metal does not absorb oxygen at ordinary temperatures, but speedily becomes blackened on exposure to an atmosphere containing the most minute traces of sulphuretted hydrogen gas, which is decomposed by it with great facility.

VASE OF OXYDISED SILVER. p. 129.

It is well known that silver, when brought in contact with eggs which have been heated, is blackened, and that this discoloration is owing to the sulphuret of silver. It was formerly supposed that this sulphuret was formed by the action of sulphuretted oil, believed to exist in the yolk of the egg, but recent experiments have led to the conclusion that the discoloration of the silver is due to the sulphur contained in the albumen, and not to that supposed to exist in the yolk.

Heated to redness, in contact with the caustic alkalies, silver does not become in the least affected, and is, for this reason, frequently employed for making crucibles to be used when attacking various substances by caustic potash. In the presence, however, of fused alkaline silicates, silver vessels, to a certain extent, become acted on, and the silicate is stained of a yellow color. Oxide of silver is reduced by heat alone, and a globule of metal is thus obtained.

On account of its softness, silver is seldom employed in a pure state, but is commonly alloyed with a certain amount of copper, by which its hardness is remarkably increased. In this way considerable quantities of copper may be added without materially diminishing the whiteness of the original metal, since a mixture of seven parts of silver and one of copper still retains a decided white color, although of a less pure tint than that exhibited by virgin silver. In order to improve the color of objects formed of alloyed silver, it is usual to subject them to an operation by which their surfaces are rendered almost free from the presence of the metal so combined. For this purpose, the article to be whitened is externally oxidized, by being heated nearly to a redness, and afterwards plunged, whilst still hot, into water, acidulated either by nitric or sulphuric acid, by which the oxide of copper formed, is immediately removed. The object, after being thus treated, necessarily presents a matted surface, from the isolation of the particles of silver; but this appearance is readily removed by rubbing with a burnisher.*

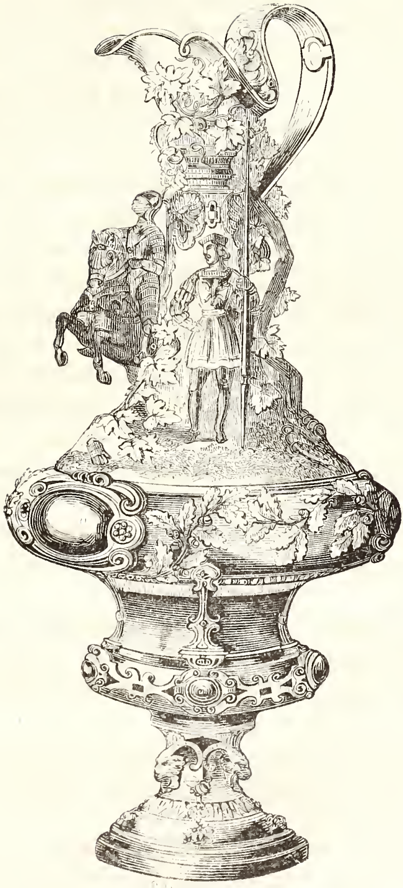
* The process of oxidation not only protects the silver from further tarnishing, but also conveys every variety of tint, from white to black, so that it is

The silver used in the preparation of coin, and for the manufacture of silver plate, consists of an alloy of silver and copper in different proportions, fixed by the legislature of the country in which the mixture is worked. In this country and in England, the same alloy is employed both for the purposes of the mint, and the uses of the silversmith; it is composed of a mixture of one hundred and eleven parts of silver and nine of copper, and is known as standard silver. In England, to prevent fraud, all silver vessels are required to be stamped by the Goldsmith's Company, who are empowered by government to search all silversmiths' shops, and seize all articles which have not been impressed with the Hall mark of the Company. For the assay of the articles, and the impression of the Company's stamp attesting its quality as standard silver, one shilling and sixpence per ounce on the weight of the object is charged. Of this amount the larger proportion is paid over to the government in the form of a tax, whilst a small sum is retained as a compensation for the trouble incurred in making the assay. In France three different standards are employed. The alloy used for the silver currency of the country is composed of nine parts of silver and one of copper; for plate, a mixture of nine and a half parts of silver to one-half a part of copper is employed, while for small articles of silver used for ornaments, an alloy of eight parts of silver to two of copper is allowed.

Silver solder consists of six hundred and sixty seven parts of silver, two hundred and thirty-three of copper, and one hundred of zinc. Besides being used for the manufacture of various ob-

particularly well calculated to display fine modelling or chasing, which would be utterly thrown away on a dazzling white material. An illustration of this is given in the salver at page 134.

Silver can be easily oxidized by taking a little chloride of platinum, heating the solution and applying it to the silver, where an oxidized surface is required, and allowing the surface to dry upon the silver. The darkness of the color produced varies, according to the strength of the platinum solution, from a light steel gray to nearly black. The effect of this process, when done along with what is termed dead work, is very pleasing, and may be easily applied to medals, giving scope for the exercise of taste.



SIDE-BOARD EUER—OXYDIZED SILVER.

jects of luxury, silver is also extensively employed for externally plating the surfaces of articles made of less expensive metals. For this purpose it is either applied to the surface of the object in the form of an amalgam with mercury, which latter metal is afterwards expelled by heat, or is deposited in the metallic form from its solution by the agency of a feeble electric current—a process yet to be described and illustrated.

German silver is composed of one part of nickel, one part of spelter or zinc, and three parts of copper; but all these substances have to be pure, and must be exposed to a great degree of heat before they will unite. The refractory nature of nickel, and the difficulty of obtaining the metal free from arsenic, iron, and cobalt, are the causes that not unfrequently we see German silver spoons of gold yellow color, while German silver prepared from pure metal will equal in whiteness sterling silver, and will not tarnish. Upwards of fifty thousand pounds of this composition are manufactured in this country annually, for which the nickel is imported from Germany and England. There are but three localities of nickel ore in this country. One at Chatham, Conn., yields about three per cent. nickel; another ore, from the mine La Motte, Missouri, yields about ten per cent., and a nickel ore has been discovered among the copper ores of Lake Superior.

Spoons and forks of German silver, when used, should be washed at once, instead of allowing them to remain soiled and dried. In this way they will always keep bright, clean, and sweet. It should also be remembered that hot water sets stains, while cold water and a little soap will prevent them. If by accident an article should become tarnished, a pinch of fine salt rubbed over it will restore the color better than any thing else.

It 1760 it is said that silver table-spoons began to supersede those of wood, horn, and pewter, in England. Silver teaspoons were rare before the time of Queen Anne. Silver forks, spoons, ladles, &c., are wrought upon the anvil in the manner of steel wares, or, in some sorts, pierced out of sheets by means of the fly, and afterwards fashioned by striking in bosses and filing. They are known according to the style of the handle. The embossed work is produced by squeezing them when red hot be-

tween figured steel dies, by means of a Bramah's press. The polishing is effected by brushing and buffing with oil and rotten stone.

The brazier is the artificer who, in a general sense, undertakes the work which requires to be fashioned or perfected by hammering and hard soldering; his art is analogous to that of the coppersmith. He is required to be conversant with all the methods of planishing, not flat pieces, but tubular, swaged and bellied work of every description. These operations are among the most ingenious of the trade; indeed, the dexterity with which a practised workman uses his hammer is astonishing. The polished steel head upon which the plate is planished is called a stake, and may either have a flat face, like an anvil, or be of a columnar or globular form, and bent so as to suit the swelling out and driving in of the parts of the teapots, basins, urns, and other articles.

These and many similar productions, are shaped in the first place by means of wooden mallets, spherical wares being always bulged out in part by placing them on a sand-bag and striking with a hammer upon an iron instrument placed inside. Silver, as also plated articles, after having been a good deal hammered, require to be lighted by being heated red hot. This requires care and attention, and the workmen have taught themselves by experience to judge of the temperature of the metal by the following simple but infallible criterion. They first black the article all over in the smoke of a lamp, and then, holding it over a clear fire of coke, mark when the filiginious film burns off, as at that time, and not before, the proper degree of annealing has taken place.

The planishing hammer for flat work has two round polished steel faces, one slightly convex and the other flat. Great care is required in planishing, not only that the strokes be made exactly level to the work, but that they be so distributed and combined as ultimately to produce one uniform and even surface, and not a series of indentations. In the earlier era of the manufacture this end was effected by the application of a vast number of slight strokes with a light hammer, as was practised by the coppersmiths. It was afterwards found that by wrapping a piece of

woollen stuff over the face of a large hammer, the marks of the rough planishing were easily assimilated; a thin piece of bright copper was subsequently added with increased good effect, and lastly a bit of hard polished sheet steel was tied over the hammer's face, a piece of moreen or some such stuff being interposed between them.

The parallel swells in most circular vessels, and the raised edge of salvers, with a variety of regular mouldings, are usually produced by means of swages. These are steel dies, grooved or ridged, the upper being a short stout lever, made to play up and down, against its counterpart below, as in the manner of tin plate working. In raising silver, however, the face of the swage, as well as the under part, requires to be covered with sheet tin, to prevent the instrument from marking the metal at every stroke of the hammer, an evil which is still further avoided by bringing a weighted cord over the upper swage, to keep it from rebounding when struck.

Although there are few forms into which an expert hammerer cannot mould such tractable metals as silver and gold, and the facilities with which others may be stamped will be apparent, yet as the former method is exceedingly expensive, on account of the time consumed, and the latter in the article of dies, the application of steam power is, in some large concerns, made to supersede to a considerable extent both methods, by what is termed spinning. This operation consists in causing a circular piece of sheet metal to revolve in contact with a model chuck of wood or other substance, upon which it is gently and progressively folded down and moulded by appropriately-formed burnishers.

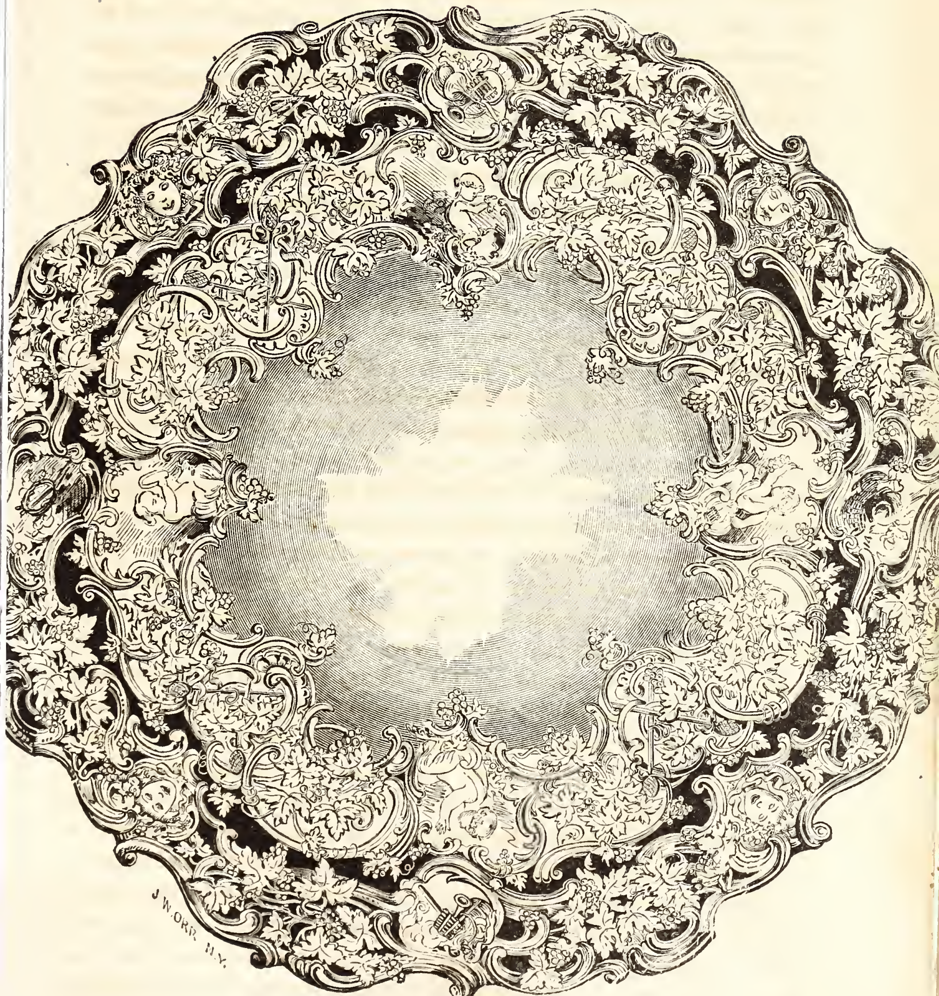
In the manufacture of silver plate there are many operations of soldering, which, on account of the situation or delicacy of the parts, or some other cause, can never be performed by the iron, nor yet over the fire. In these cases recourse must be had to the use of the blow-pipe and the flame of a large lamp with a great wick, or a jet of gas. The latter is used when it can be had, and is found to be the cleanest, readiest, and most economical for the purpose.

One very ingenious department of the manufacture consists in

what is called chasing or embossing, these terms being used respectively as the work is superficial or deep in the execution. To this practice the goldsmiths of antiquity are much indebted for the perfection of their wares: it is indeed a process which, next to the art of engraving, and with much greater effect, exhibits in wonderful perfection the designs of the draughtsman. It embodies not merely outlines with bold relief, but superadds diversity of texture, surface, and even color; and some pieces, wrought of the precious metals and ornamented in the first style of art, are of great value. The method of performing the work is very simple as to details.

When the article has received its form at the hand of the brazier, the design is in the first place delineated upon it in a very slight way, or, if it be not original, by means of red chalk and tracing-paper, after the manner of transferring a design to the copper plate by the engraver. The work, if at all hollow, and if the figures are to be in relief, is held upon a sand-bag, and the body of the design is bulged from the inside by the application of a hammer upon a knobbed rod called a snarling iron; the vessel is then filled with a composition of pitch and ashes from the grate, and rested upon the sand-bag during the operation on the outside, when the work is perfected. If it be a salver or other flat article, it is embedded upon a quantity of the composition laid on a board of the proper size, and having a hemispherical under-piece resting in a cavity on the work-bench, by which contrivance it is readily turned about by the chaser, so as to suit his convenience. The lines are then sunk by striking down upon and indenting the metal with little blunt steel punches of shapes adapted to the figure. In this way the most elaborate designs can easily be brought up into bold relief by a skilful workman.

When the articles are finished in all their parts, the edges dressed, the ornaments soldered on, and the chased or embossed work executed, they are boiled in a lixivium of pearl ashes, to take away the rosin or grease which may remain attached, after which the raised parts are got up by dry brushing, and finally by burnishing. The burnishing is an operation to which plate is indebted for that lustrous appearance, so peculiar to the precious



SALVER—(SILVER.) p. 1[illegible]4.

metals when thus finished for the market. The burnishers comprise those of steel and those of blood stone; the latter is fixed by means of cement in ferrules attached to the hafts: they are of various forms, suited to the purposes for which they may be required.

In burnishing, (which is generally performed by women,) the first process is to touch the article over with a little brown soap and water, to counteract any greasiness, and then they apply a rough stone burnisher (called rough only as it is less exquisitely polished than the others) to obliterate any scratches which may exist, and, as it were, lay the ground. This is followed by a steel tool, then comes the middle stone, and lastly the fine stone is used. These stones, during the using, are occasionally dipped in water in which white soap has been dissolved. The articles are finally wiped up with a piece of soft chamois leather.

In some silver articles there are parts, particularly representations of the human figure, and also animals, which are exhibited in matted or dead work, of a fine white ground, in contrast to the burnished portions. This effect is produced by covering the subject with a coat of pulverized saltpetre and charcoal, quenching it in a pickle of *sal enixon.* Sometimes the first operation will be sufficient, but if not it must be repeated until the fine white ground is produced. In some very rich and massive pieces of plate, the figures, instead of being stamped or embossed in sheet metal, are cast from designs modelled expressly by celebrated artists and copied in plaster of Paris.

The soft nature of wax was too ready a material for modelling not to be used by sculptors and goldsmiths from the earliest times. The Greeks and Romans modelled figures in wax, and the art was practised in Italy from the era of the Renaissance. All the celebrated Italian goldsmiths of the fourteenth and fifteenth centuries prepared models in wax of their exquisite compositions, and the great artists made their first attempts upon this material. Luca della Robbia had learned to model from Leonardo, the most skilful goldsmith of Florence. The celebrated Ghiberti, compelled to leave Florence in 1400, on account

of the plague, employed himself during his exile in modelling in wax and stucco; and the model made by Cellini in wax of his statue of Perseus, preserved in the Gallery at Florence, is very superior to the bronze.

In modelling, the workman uses his wax much in the same manner as the sculptor employs his clay. He gradually works it into the required form by means of modelling tools, generally made of boxwood, and all the details are nicely wrought out in this material. Then a paste is made of plaster-of-Paris and water, which is poured over the wax and allowed to set. When dry, it is removed, and is in turn filled with wax to the thickness of the required casting. A follower is made of plaster, to fill up the rest of the space, and then a channel, leading from the exterior, is opened to the wax, and a passage is also left for the escape of the melted wax. Molten lead is now poured in, which occupies the place that the wax filled, and when cooled and removed, we have the design in lead, which is handed over to the moulder. He moulds it in sand, precisely after the manner described for moulding iron castings, and if the work is to be used with little additional finish, great care is taken in moulding, but if it is to pass through the hand of the chaser before it is completed, less time is spent over it.

When the sand mould is ready, the molten silver is poured in from the crucible, and it takes the place made vacant between the flasks, by the removal of the lead pattern. In this way all ornaments are cast, and the casting of every article that presents two surfaces is made in two parts. Borders present but one surface for inspection, the other being soldered to the vessel they adorn. But the handles, spout, little raised figures, and the like, are cast in halves, and when finished, the two halves are joined together with hard solder, so nicely that it would be difficult to find the joint. The casting, thus completed, is hollow, and if the metal is of a proper thickness, it will stand all ordinary wear without injury, but if made very thin, as is sometimes the case, with those who seek only to realize largely from their manufactures, they must be filled in with some compound, to give them a

SILVER CENTRE PIECE—SUBJECT, SIR ROGER DE COVERLEY AND THE GIPSIES.

degree of solidity. The value of such articles cannot be determined in the scales.

All the little ornaments in silver ware are cast, finished up by the chaser, and soldered on—with the exception of a few very simple devices, which are rolled out by means of machinery. These last require no additional finish at the hand of the chaser, and they generally consist of a little vine, a few leaves, or the fret or key ornament, which last appears to be common to all periods of art.

The consumption of gold and silver, at the present day, for household purposes, is enormous, and its application has increased rapidly since the discoveries of gold in California and Australia. The amount of gold and silver annually taken from the mines of Europe, is valued at twenty-five millions of dollars. In America the yield is computed to be one hundred and forty-six millions, and Asia produces twenty-five millions. Africa has no silver mines, but produces gold to the amount of two millions six hundred thousand dollars. Australia is also without silver, but gives gold to the large amount of two hundred millions. The whole sum extracted since the earliest time, is worth, together, something more than twenty billions, five hundred and thirty-six millions. Of this sum, there had been extracted at the commencement of the Christian era, four billions, three hundred and twenty-eight millions. The increase in the production of gold and silver is enormous, and we shall, at the present rate, gain more in this respect, in fifty years, than our ancestors did in fifty centuries. The total amount of gold and silver extracted in America, up to the close of 1855, is only about twenty millions less than the entire product of the Asiatic mines since the beginning of the world, while it is more than double the entire past yield of all the mines of Europe, Africa, and Australia put together.

The first discovery of gold in Australia, was made by a bushman, who knew nothing of its worth. The lump was valued at more than £5000, and he parted with it for a new suit of corduroy. An immense lump of quartz gold, found in Calaveras Co., California, weighed one hundred and sixty-one pounds, twenty of which, it was estimated, were made up of quartz. It was valued at $38,919, which exceeds the value of any other lump that has

yet been brought to light. In the cabinet at St. Petersburgh, there is a lump of gold which weighs seventy-eight pounds.*

An instance of almost unexampled prodigality in the waste of silver in the ceremony of barbaric splendor, was witnessed at the interment of Radama, a native king of Madagascar. His majesty expired in a building, called, from the immense quantity of this precious metal with which it was plated and studded, the silver palace, and the coffin in which he was finally deposited in the tomb, was eight feet long, three and a half feet deep, and the same in width, composed of silver plates and rivets, in the making of which, twelve thousand Spanish dollars had been worked up; besides this, twelve thousand hard dollars were laid in the coffin, by way of a cushion for the corpse. Into the grave was also thrown articles of great value, including the whole sideboard of silver plate, belonging to the deceased.

A tomb recently opened in Southern Italy, and which is supposed to date from the time of Alexander the Great, revealed many exquisite specimens of wrought gold. The ground was covered over with gold thread, supposed to be the remains of a golden carpet or cloth, whilst round the walls were disposed more than forty vases, of various, though graceful and elegant shapes. In harmony with the idea that the deceased would resume the habits of this life, in another world, the skeletons bore upon them the traces of the most magnificent dresses. The principal female figure was found with ear-rings, representing two peacocks, not merely in shape, but in tint; the colors of the plumage being given by smalt upon gold. Gold bracelets of a serpent form surrounded the bones of the arm. The vest had evidently been embroidered, for garlands of myrtle, both the leaf and the berry, were found in the gold, and all clearly pierced with the holes by which they were once attached to the dress. Round the head was a diadem of various flowers, the cups of which were formed of rubies, and jacinths, and emeralds of great beauty, and sometimes of smalts of different colors. A beautiful ring

* The late reports of the discovery of several lumps of extraordinary dimensions, lack confirmation.

was found on one of the fingers of the female. The circle was formed of two clubs of Hercules, the point where they met being surmounted by a ruby, whilst the upper and opposite part of the ring was a box. This work, described as of the most beautiful filigree, displayed a great variety of beautiful forms, and was regarded by all with astonishment, leaving a doubt whether modern art could produce any thing so perfect.

Large quantities of gold and silver are required in the manufacture of watches. The number of these annually made in Neufchatel may be calculated to be from one hundred thousand to one hundred and twenty thousand, of which about thirty thousand are in gold and the remainder in silver. The United States consume the largest quantities of these watches. With the exception of the gold and the silver for the manufacture of the cases, the other materials for the construction of the works or mechanism of the watch are of little value, consisting merely of a little brass and steel.

It is generally known that watches of American manufacture are now coming into extensive use. They are characterized by several features of special peculiarity. The first of these is the absence of the fusee and chain. Those parts, which were very necessary for equalizing the force in the old verge watch, are continued by the English in the modern lever watch; but in the Swiss watches, which perform so excellently, no such parts exist. The second feature is such an arrangement of the parts as to lessen the liability of the watch to stop from the presence of foreign substances, and at the same time to facilitate the discovery of any cause of derangement, almost the entire tram being open to view. The third and distinguishing feature is the principle of making every watch and every part the duplicate of every other. This plan has been so far adhered to that every movement will fit every case, and many parts can be transferred from watch to watch without alteration. Any deficiencies in the carrying out of this principle are in great part remedied by a system of registration at the factory.

A number of curious watches were exhibited at the London Crystal Palace, one of which runs a year, another showed the

time to one-sixth of a second, and a third was made of ivory, with gold screws and steel moving powers. It worked in ten rubies, and weighed, glass and vase included, half an ounce. There were some of the finest specimens of miniature watches exhibited, that probably have ever been made. These timepieces were set on card cases, the frames of eye-glasses, brooches, rings, &c. Some of them were scarcely the size of a gold dollar, although somewhat thicker. The top of a gold penholder, richly set on rubies, contained a timepiece with three dials, each one quarter of an inch in diameter, running a week without winding up, and showing the months, days, weeks, hours, and minutes.

Among the clocks there was one run by the equilibrium of water and air, very ingeniously constructed. A clock in a case, which occupied thirty-four years in completing it, with astronomical, chronological, and other movements, wind organ, &c. A geographical clock, showing the days of the month, the months of the year, the motion of the sun and moon, and the state of the tide at some of the principal seaports of Great Britain, Ireland, France, America, Spain, Portugal, Holland, and Germany, and going for twelve months. A skeleton clock, giving four hundred days, and showing dead seconds by means of a chronometer. A patent tell-tale clock, for the purpose of regulating domestics, and a clock called the perpetual motion clock, having no weights or chains, and most curiously made.

And as an offset to these we may here give the dimensions of the clock in the new house of Parliament. The dials are twenty-two feet in diameter, and are the largest in the world. Every half minute the point of the minute hand moves seven inches. The pendulum is fifteen feet long; the wheels are of cast iron; the hour bell is eight feet high, and nine feet in diameter, weighing from fourteen to fifteen tons, and the weight of the hammer is four hundred pounds. The mere winding of each of the striking parts will take two hours. The clock will go eight and a half days, but will only strike for seven and a half, so as to indicate by its silence any neglect in winding up.

Until the tenth century time had only been measured by the aid of sun-dials, clepsydras, or hour-glasses. The invention of

ORNAMENTAL CLOCK.

p. 160.

clocks with tooth wheels, kept in motion by means of a weight, is attributed to the celebrated Gerbert, a French monk, who was ultimately elevated to the popedom under the name of Sylvester II.

In the first clocks the hour alone was indicated by a hand, which was fastened on the axis of a wheel. It was not till the twelfth century that a mechanism was invented for the purpose of striking with a hammer upon a bell the hours which the hand indicated upon the dial. Small clocks, suitable for the interior of houses, were in use at the end of the thirteenth century, but they could not have been common till a much later period.

An improvement introduced in the art of clock-making, towards the beginning of the reign of Louis XI., caused a great extension of the manufacture of clocks: the invention was that of the spiral spring, which, secured in a barrel or cylinder, replaced the action of the weight attached to a string, which had hitherto been made use of as the moving power. This spiral spring, moving easily in a very narrow space, allowed of the construction of portable clocks of very small dimensions. Carovage, or Carovagius, who lived in 1480, is considered as the inventor of portable clocks, with striking bells and alarms. This invention of a Frenchman excited the emulation of the Italian and German clockmakers, who vied with each other in producing the most extraordinary clocks.

These portable clocks soon led to the construction of still smaller pieces, distinguished by the name of watches. Their invention does not appear to date back beyond the first years of the sixteenth century. The first watches made in France were of a cylindrical form; at Nuremberg, on the other hand, they received an ovoid form, which obtained for them the name of "Nuremberg eggs."

In 1657, Hughens, the celebrated mathematician, brought great modifications in the art of clock-making, by applying the pendulum to clocks, in order to regulate the movement, and adapting, some years later, to the balance of watches a spring, which produced upon this balance the same effect as that of the weight upon the pendulum.

Fourteen hundred years before the Christian era, rings of gold, with devices and legends engraved upon them, were in use, and in respect to the fashion of these rings, the same is now employed to give a value to modern works of a like description. In the earliest chapters of the Bible we find mention made of rings and other ornaments in silver and gold. Of such the Israelites borrowed of the Egyptians when they left the land of bondage for one flowing with milk and honey, and anterior to that remote period the Hebrews were in possession of such works, probably of their own design, for among the presents given to Rebecca were a golden ear-ring and two bracelets. And throughout the Old Testament may be found passages referring to personal adornments, such as that in Ezekiel, where the prophet says, "I put bracelets upon thy hands and a chain on thy neck, and I put a jewel on thy forehead and ear-rings in thy ears," which description will answer equally well for the present mode of wearing jewels and other ornaments.

From the Egyptians the Greeks and Romans, as well as the Persians and Chinese, derived their knowledge of the arts, and chains and rings of gold were brought early into general notice by these nations, though the manner of constructing the chain was somewhat different from that of the present day, the latter being composed of an infinitely greater number of pieces. Those made of silver, in certain portions of Russia, are not larger round than an ordinary thread. They are principally made by women, and are worn by the lower classes to suspend their crosses.

The Egyptian women were extremely partial to the wearing of rings, either of gold or porcelain. Of these they often had a number on every finger, and on the thumb also. The left, as with us, was the favored hand, and as many as eight rings have been found on the hand of a mummy; in all cases the greatest number were on the third finger.

Pure gold is never required for jewelry, any more than for coin or articles of domestic use. It is usually alloyed by introducing a small quantity of silver or copper. Silver renders it lighter in color, and copper gives it a deeper shade, inclining it to a reddish hue. For the use of the jeweller a greater amount

of alloy is often introduced, even to one-third or one-half, but the manufacturer who values his reputation, and who is engaged in making the better class of articles, uniformly uses gold of twenty-two carats. Even then the proportion of gold is very small, as will be seen by the following description of the process of manufacturing.

The jeweller of the present day relies in a great measure on dies for the forms he gives the articles that come from his hand. These he has cut in steel with care, and many of them are beautiful, and often they are very intricate. The gold is rolled out into strips, and what we behold is all that it professes to be—pure gold; but the proportion of the metal to the whole is very small. A strip of gold, not thicker than a silver dollar, is secured to a bar of brass of corresponding size, but much thicker in proportion. A flux is applied, to unite the two, and the mass is subjected to the action of the fire. At the proper moment it is withdrawn, and when cool the two metals will be found firmly united. The bar is then rolled out between cylinders set in motion by steam power, and this operation is continued till the metal, in the form of a long ribbon, is not thicker than letter paper. It is then cut into small pieces of the size required, and the workmen so places them in succession that the die falls upon each in turn, giving to it the required form. As the die rises, the piece last struck is removed, and another piece is placed over the socket, ready to be struck when the die comes down again. The die is attached to a heavy weight, which gives force to the blow, and it is guided by a grooved framework, in which it travels up and down, at the will of the workman.

If a ring is to be made, the outer half, with its ornamented surface, is struck at one blow. A number of these halves are filled with lead, which, when melted, fills up all the inner surface, giving the article weight, and rendering it stiff and firm. Each piece is then taken in turn and receives the back or inner surface, which comes in contact with the finger, and the edges are joined by means of the blow-pipe; the whole is then heated in a jet of gas, so that the lead is once more melted and adheres to all the parts, making it a firm and consistent whole.

The burnishing and polishing then follow, on wheels coated with tripoli, emery, and rotten-stone, and if the pattern requires an additional finish at the hand of the chaser, it is passed over to him. To give it a sufficient body to stand the blows from his hammer, he fills the circle with lead, run into it, and fitting all the parts perfectly. Then he secures it firmly to his bench, and without any pattern before him, he works the surface into the form of flowers, scrolls, and figures. It then receives a fine polish, and is passed over to a girl who puts it up for the market.

When filigree work is introduced, the wire is drawn out by means of machinery. For this purpose the gold must be quite pure. The two-thousandth part of lead is said to render gold so brittle as to prevent its being drawn. The form into which these wires, plain and variegated, are wrought, is governed by the taste of the workman and the requirements of the market.

Too often there is a display of much that may be set down as in bad taste, and novelty takes precedence, even to the exclusion of articles worthy of the highest consideration. Precious stones are frequently so set as to lose their finest qualities, and in drinking-cups and sword-handles they are wholly out of place. The beauty of jewels depends on their power of emitting or reflecting light, and, to exercise this function efficiently, the light must be intermittent, or given off in flashes, which effect cannot be attained except by a constant change of position of the reflecting surface, such as that to which they are subjected when employed as a personal ornament.

Jewelry of value is made with great care, and will bear the closest inspection and constant wear. The joints and seams are closed with hard solder, and the chasing is often after the most exquisite designs. Enamels and precious stones are introduced with due regard to the end had in view, and such articles lose not their value with every change of the fashion. They may be regarded as works of art in the precious metals, and time, so far from depreciating their value, only adds to it.

We cannot here enter into any details in regard to the money of the ancients, which was very rude at best, and, in fact, a century has hardly elapsed since the time when any thing like im-

provement was effected in the character of coined money. The first mention that we have of the precious metals is in the form of money, though the circulation of these metals for that purpose was governed wholly by weight. Articles of almost every description have been made a circulating medium by the various nations of the earth. The Lydians originated coined money, and began with gold. The Persians also used gold for this purpose. Greece started with silver; hence, in the Greek tongue, silver and money are synonymous. Rome had ultimately silver and gold, but copper was there first used, and copper and money are synonymous in their language. In shape we have pieces of money in the form of rings, pieces struck with a die, and pieces cast. First one side was ornamented, the other retaining the rude marks of the punch; then both sides were embellished. And from these we pass on from initial letters to names, then from one word to several, from a head to an entire figure, and from one figure to elaborate groups.

Silver and gold are coined, at our mints, into dollars, halves, quarters, dimes, half-dimes, eagles, half-eagles, and quarter-eagles.

Any person bringing good precious metal to the mint, for coinage, is entitled to receive back, in American coins, exactly the same amount of fine gold or fine silver which he brings, without deduction or expense; the United States Government taking upon itself the expense of coinage. If the bullion, containing both gold and silver, require the operation of parting, or, if toughening be required, then the actual expense of these operations is deducted from the value of the bullion, in favor of the government. Bullion is received by the treasurer, weighed in the presence of the owner, by the weigher, who gives a receipt for the actual weight, in troy ounces and decimals. If it consist of mixed coins, or various bars, it is sent into the melting department, placed in a red hot, clean black-lead pot, melted, stirred up and mixed, and cast into a homogeneous bar. It is next given to the assayer, who cuts off a piece of the bar, rolls out the piece, clips it with shears, and weighs out exactly one thousand milligrammes thereof, which he wraps up in lead and places upon a white hot dish of bone-earth; the whole melts, and, oxidizing,

every thing present is usually absorbed by the bone-earth but the silver and gold. If pure silver alone remain, its weight in milligrammes shows how many thousands fine the bullion is. The result is, however, corrected by what is called the humid assay, which depends on a definite precipitation of chloride of silver, from a solution of nitrate of silver, by definite measures of a solution of common salt of known strength. If the assay be one of gold, after the buttota of metal has been removed from the bone-earth, it is melted with about three times its own weight of pure silver, the alloy is rolled out and repeatedly subjected to the action of hot nitric acid, which dissolves and removes the silver, but leaves the gold. The latter is carefully washed, dried, annealed at a red heat, and subsequently weighed in milligrammes, by which the proportion of gold in one thousand parts is made apparent. With these data, the assayer then estimates the value of the bullion, whereupon, the treasurer, if called upon, promptly pays the amount to the owner.

Parcels of bullion, of known value, are, from time to time, delivered to the melter and refiner, who manufactures the same into ingots for the use of the coiner. Upon the receipt of bullion, the melter and refiner assorts the bars into the following classes: A, ready to be made directly into ingots; B, requiring to be toughened; and C, requiring separation.

A. A melt is made by arithmetical calculation, from bars of the class A; some above, some below the standard in title, so that the result of melting and mixing may produce ingots 900-1000ths fine. In case of silver, about seven thousand troy ounces, equal to four hundred and eighty pounds, avoirdupois, are melted in a large cast-iron pot, or crucible, surrounded by a charcoal fire, in a wind or draft furnace; and when the whole is in a state of fusion, the mass is diligently stirred, and then, by hand, laded out and poured into smooth iron moulds, making smooth ingots about sixteen inches long. Gold is likewise melted in this manner, and cast into ingots into black-lead pots, each holding about sixteen hundred ounces, near one hundred and ten pounds avoirdupois. The assayer next ascertains that the ingots cast are of the legal

fineness required; if not, they are condemned, and have to be remelted.

B. Bullion containing any thing but gold, silver, and copper, usually requires to be toughened, an operation commonly performed in the mint, by repeatedly casting nitre upon the surface of the melted metal, stirring it about, and then skimming it off, with the dross from the base metal contained.

C. The mint processes, followed for the separation of alloyed gold and silver, are as follows: in the first place, the mixed bullion, if required, is melted with additional silver, so that the alloy may contain about three times as much silver as gold; the melted metal is poured in a small stream from a height of a few feet, into cold water, by which means it is obtained in a finely granulated condition; the granulated metal, placed in a glass mattress, supported upon a sand-bath, is boiled with nitric acid, which dissolves the silver, but leaves untouched the gold in the form of a dark powder. The dissolved silver is poured into a tub of strong brine of common salt, by which it becomes converted into a white powder, the chloride of silver. After repeated washing, the chloride of silver is subjected to the joint action of metallic zinc and hydrogen gas, by which means it becomes changed to pure, finely-divided, solid silver. After being washed and dried, it is melted with nitre and borax, and cast into bars. The dark powder of gold is also carefully washed in hot water, dried, and in like manner cast into bars.

Consequent upon these operations, more or less gold and silver becomes mixed with ashes, dross, dirt, &c. All these matters are finely ground and washed, smelted, &c., for the extraction of the precious metal. But there will still remain a valuable residue, for which reason the sweepings will be treated like poor gold or silver ores.

The gold and silver ingots, cut and trimmed, and their fineness or quality approved by the assayer, are next transferred by weight, through the treasurer's office to the coiner. In the coining department, they are repeatedly passed lengthwise between smooth and powerful iron rollers, being annealed from time to time in a large annealing furnace, until, by the compression, the

metal assumes the form of long, thin strips, the thickness of which approximates to that of the coin to be manufactured. The annealing strips, covered with a thin coating of wax or tallow, are then taken to a Burton's drawing machine, where, being drawn between polished steel surfaces, on the principle of wire-drawing, the thickness is reduced exactly to the extent required. To attain this nice result, the steel surfaces are adjustable, and trial pieces are punched out and weighed. The drawing machine, as here arranged, is an admirable piece of mechanism. If the strip be drawn a fraction too thin, which seldom happens, it is condemned and returned through the treasurer's office, with all the residual clippings, to the melter and refiner, who consigns the whole to the melting-pot.

The approved strips are next submitted to the action of a circular punch, which, at the rapid rate of one or two hundred per minute, cuts out the planchets or blank pieces of the required size for the coin intended. A most curious mechanical process is that next in order, raising milled edges upon the planchets. They are rolled with great velocity edgewise between approximating circular steel surfaces, so that raised edges are produced at a rate, depending upon the size of the pieces, from one to seven hundred per minute. All the form-changing operations are now completed, preparatory to the actual coinage. Annealing and cleaning have next to be attended to. The planchets, with wax or tallow still adherent, are now heated to a dull redness, in iron recipients placed in the annealing furnace, and poured, hot as they are, into a tub of diluted sulphuric acid, by which means all impurities are removed from their surfaces, the alloyed copper superficially dissolved away, and the clear, beautiful, dead white appearance of unburnished silver is elicited. Adhering acid is washed away in water, and adhering water dried away by hot mahogany sawdust, in an ingenious rotating apparatus heated by steam.

The coining consists essentially in compressing the prepared gold or silver blanks, with very great force, between engraved dies of steel, of extreme hardness and high polish. The mechanical principle brought into play is the same as that in the ordinary

printing-press—the genicular or elbow power, by which, with sustaining parts of sufficient strength, an almost incalculable degree of pressure may be commanded. Each operating press requires a man to watch it, to oil the joints occasionally, and to keep a vertical brass tube supplied with the blanks or planchets to be coined. The untiring press goes on, seizing with iron fingers from the tube a planchet of its own accord, carefully adjusting it to the retracted dies, squeezes it with a force wonderful to contemplate, and then quietly and safely depositing it in the box placed to receive it. From eighty to one hundred and fifty pieces, depending upon the size, are thus coined in one minute's time. The obverse, reverse, and indented work upon the edge, are all completed at a single effort of the press.

Though stamped and perfectly finished, gold and silver do not legally become money until the coiner has formally delivered it to the treasurer. It must be seen that the pieces possess the weight required by law. If any prove too light on trial, a circumstance that rarely happens, such are defaced and condemned, to be remelted.

CHAPTER IX.

ENAMELS.

ENAMEL is simply a vitreous paste, resembling glass, and derives its color from metallic oxides, it being either transparent or opaque, according to the nature of its component parts. All metals may be employed for the groundwork, with the exception of brass, which fuses at too low a heat to melt the enamel. But on gold, silver and copper, it can readily be employed as a means of ornament. The colors usually employed in enamelling are blue, green, red and white; the first is derived from cobalt, the second from copper, the third from iron or gold, and the last from tin. The manner of preparing and using them we shall have occasion to refer to.

The art of enamelling is of very early date, and its application to ornamenting articles of domestic use, may be traced among almost all the civilized nations of antiquity. It was practised by the Egyptians, and articles richly ornamented with enamel have been discovered amid the ruins of Nineveh and Babylon. The art was known in England in the time of the Saxons, and at Oxford there is an enamelled jewel which belonged to Alfred, and which, as appears by the inscription, was made by his order about A.D. 887.

Enamel is applied to metals in three different ways, which are severally known as incrusted, translucid upon relief, and painted. In the first kind, the metal describing the outline of the design,

and sometimes every portion of the figure, receive into interstices previously prepared, the vitreous matter which gives the coloring of the subject, or sometimes only the ground. In the second, the design is executed by means of a delicate chiselling, in bas-relief, upon the metal, the surface of which is covered with translucid enamels. In the third kind the metal only answers to the canvas or wood in oil painting. Vitrifiable colors are laid on with a brush, and produce at once the design and the coloring.

Incrusted enamels are subdivided into two classes, the one known by the name of *cloisonné*, and the other is called *champlevé*. The different manner of disposing the metal for forming the outline of the design has given rise to this distinction.

For the cloisonné enamels the plate of metal was provided with a rim, for the purpose of retaining the enamel. Slender strips of the metal, of the same width as the rim, were then taken and bent in short lengths, and fashioned in such a manner as to form the outline of the pattern. These short bits were then joined together and fixed in an upright position upon the plate. The intervening spaces were then filled up with the various enamels, reduced to a fine powder, and moistened into a paste. The piece was then placed in the furnace, and when the fusion of the vitreous matter was complete, was withdrawn with certain precautions, that the cooling might be effected very gradually. If in the firing the enamel had sunk below the level of the rim, and the other strips of metal, it was again overlaid with a very fine coating, and the piece returned to the fire.

Pure gold and very fusible enamels were necessary for this process, in order that the plate might not undergo any alteration from the action of the fire, or the delicate strips of metal be melted by the heat which fused the enamel paste.

In the champlevé enamels, as in the cloisonné, a delicate line of metal describes on the surface of the enamel the principal outline of the design; but the outline, instead of being arranged separately, and then applied to the plate which is to receive the vitreous matter, is formed out of a portion of the plate itself.

After having prepared and polished a piece of metal varying in thickness from one-twenty-fifth to one-fifth of an inch, the artist

traced out those parts of it which, being kept on a level with the surface of the enamel, were to form the outline of his subject; then with scalpers he tooled or hollowed out all the spaces to be filled by the different enamels, leaving certain slender lines which served to keep the enamel colors distinct, and to define the principal outline. In the cavities thus prepared he introduced the vitreous matter, either dry or purified, or reduced to the consistency of a paste by means of water or some glutinous liquid. The fusion of this was effected by the process already described.

Cloisonné enamels are usually enclosed in a little case of metal, in which the figures are composed of enamel, as is also the background upon which they are represented. In this little case the outline alone is formed of metal, by means of slender lines, which are slightly attached by their edge to the plate at the back. But sometimes it is the metal which serves as a background to the picture, and in this case a portion of the field or plate of the metal, corresponding with the space to be occupied by the figure or subject, has been scooped out or removed for the purpose: the lines of the outline being still expressed by very delicate strips of metal inserted in this raised part. The flesh tints are always expressed by enamel, which the artist has endeavored to assimilate as near as possible to the natural color of flesh. The palette of the Greek enamellers was very rich; the colors they used were white, bright red, brownish red, dark and light blue, green, yellow, violet, flesh color, and black. White, black, and lapis-lazuli blue are always opaque, the other colors are sometimes opaque, sometimes semi-transparent; yellow is of rare occurrence.

The cloisonné enamels were generally executed upon gold, in pieces of small dimensions, which were then enclosed in a setting or collet, and fixed upon the objects they were destined to ornament, and in the same manner as the precious stones with which they were alternately placed. These little plates of enamels having thus been prepared separately, it follows as a natural consequence that they often have been used in the decoration of pieces for which they were not originally made. Thus we find Greek enamels upon French, Italian, and German monuments, and the

age of these monuments is not always a true criterion by which to determine the age of the enamels, which are often of more ancient date.

The cloisonné enamels were in great repute, and were employed in the decorations of objects of every description, and particularly crosses, shrines of holy relics, and caskets. Swords, crowns, and even vestments, were enriched with enamels of this kind. The gloves which formed part of the imperial costume of Charlemagne, preserved in the treasury at Vienna, are embroidered with pearls, and ornamented with little plates of cloisonné enamel.

Champlevé enamels are almost always executed upon copper; the cheapness of the material admitting the use of plates of large size. These enamels are not, like the cloisonné enamels, attached as ornaments to pieces of jewelry or plate, but are mostly, on the contrary, complete works of art in themselves, and, owing to the depth of the sculpture and the thickness of the enamel, possess great solidity, and are durable in their colors. The vitreous matter is employed in two ways: sometimes it gives the colors to the carnations or flesh tints, the draperies, and the ground, and in that case the metal which touches the surface serves merely to trace the principal outlines of the design; at other times it is employed to color nothing but the ground, and to form a border round the figures of gilded metal, which are either expressed by fine engraving on the plate, or are chiselled in bas-relief.

The practice of representing the flesh tints by enamels approaching the natural color, and of using colors in the draperies, is peculiar to the eleventh and twelfth centuries. When the figure was very minute, the enamellers of that period expressed the carnations by lines incised on the gilded metal; the draperies were then colored.

The second manner of disposing the enamels, which consists in employing it only for giving colors to the ground, was that almost exclusively adopted in the thirteenth and fourteenth centuries. It is difficult to meet with enamels of this period in which the figures are expressed otherwise than by fine engraving on

the gilded metal, or else by reliefs upon the enamelled ground, which is nearly always of a brilliant blue. The evident progress made in the art of drawing in the thirteenth century, was doubtless the principal cause of this alteration in the process.

The art of enamelling by incrustation lost much by the change; as soon as the enameller, confined to the work of coloring the background, became a mere auxiliary to the graver, he lost his position as an artist, and descended to that of a machine. The facility of executing works of this description occasioned their production, which led to the depreciation and eventually the extinction of this fine art.

The painting on incrusted enamels had all the faults of the early mosaics: the same stiffness of outline, either absence or crudity of shading, want of perspective and parallelism of the figures, which were either isolated or placed upon a single line. The brilliancy of their imperishable colors was insufficient to atone for these faults in the eyes of the great Italian artists, who, during the second half of the thirteenth century, shook off the Byzantine yoke and struck out into new paths of art. Without giving up the use of enamel, which, by the brilliancy and durability of its colors, was eminently calculated for the decoration of works of the goldsmith, they sought to employ it in another manner, and to adapt it to the productions of their genius.

On the other hand, the immense riches of the clergy and the progressive increase of luxury, occasioned, in the fourteenth century, the almost exclusive adoption of gold and silver for all vessels for sacred use, and the plate of the nobility. The sacred vessels and reliquaries were now made of these costly materials only; and the altars were overlaid with bas-reliefs richly chased in gold and silver.

Enamel work by incrustation, which required plates of metal of considerable thickness, did not meet the exigencies of the goldsmith, who, in multiplying the number, diminished of necessity the weight of the objects he produced.

Such were doubtless the different causes which brought about, in Italy and France, a change in the manner of applying enamels. The incrustations of enamel upon vessels of gold and silver were

replaced by fine chasings, the ornaments and subjects selected by the artists; the surface of these was afterwards colored by fine translucid enamels of most brilliant hues, and so incorporated with the chasing as to give to the whole the appearance of a finished painting reflecting a metallic lustre.

The process was as follows: On a plate of gold or silver, often very thin, the artist marked out by an incisure, formed to receive the enamel, the outline of the space that the part to be enamelled was to fill; then, with very delicate tools, he engraved on it the figure or subject he wished to represent; the more prominent parts of the flesh and draperies then presented a very slight relief, and the lines of the face were often only expressed by engraving.

In the beginning of the fourteenth century, when in the hands of the most skilful artists the art of enamelling was brought to perfection, the plate was prepared in a different manner. The plate of gold or silver was fixed by heat upon a stucco composed of pitch and ground brick, mixed with a little wax. After that, having traced with a compass the outline of the space to be filled, all that part of the plate was depressed to a depth corresponding with the thickness which was judged suitable for the enamel. The artist then drew upon this depressed portion the subject to be represented, and afterwards, with very fine tools, engraved it in relief to a thickness equal to that of two sheets of paper.

An extensive variety of colors was used in this kind of enamel. We find greens, pinks, reds, violets, grays, blacks, several kinds of brown, and light blue. White and lapis-lazuli blue, which are always opaque, are not used; and as the flesh color must always be based on a white enamel, which also gives opacity, the flesh-tints in these enamels upon relief are expressed by the metal ground itself, seen through either a colorless enamel, or one slightly tinged with violet.

Translucid enamels upon relief are not so rare as the Cloisonné enamels, but as the utensils of domestic life which were decorated with them have been destroyed through change of fashion, these enamels are most frequently to be found in the treasures of

churches, upon sacred vessels or reliquaries, which have owed their preservation to their sacred character.

When, towards the end of the fourteenth century, works of copper enamel, which had been so esteemed for nearly four centuries, were now losing their value through the increasing taste for materials of gold and silver, and the translucid enamels that decorated them, the Limousin enamellers (who had been long celebrated for their skill in the art) were compelled to invent some new mode of applying enamel to the representation of subjects. These endeavors gave rise to the invention of true painting upon enamel. The process employed in this new kind of enamel essentially differed from those hitherto in use. The enamellers no longer required the assistance of the graver to express the outlines of the design; the metal was entirely concealed under the enamel, and if any of it remained subjective to the painting, it was in the same manner as wood or canvas in oil painting; the enamel spread by the pencil upon the surface expressed at the same time the outline and the coloring.

It was probably the modification introduced in the fourteenth century, in the art of painting upon glass, which suggested this new style of enamelling. Mosaic grounds of colored glass were at this time almost entirely discontinued, and artists had begun to paint superficially upon glass with enamel colors. From that time it became evident that what was done upon glass might also be done on copper, with the difference only of giving, either naturally or artificially, complete opaqueness to the colors.

The first attempts at this new kind of painting were, of necessity, very imperfect. The enamel colors of that date are applied upon the metal in layers sufficiently thick to admit of the movement of the drapery which covers the shoulders of a representation of Saint Christopher, and the agitation of the waves which bathe his legs, being expressed by inequalities of the enamel paste, which is of an uniform color. The drawings of these first attempts is always very defective. The enamel colors are applied immediately upon the metal itself, and are only attached by the fusion which determine the degree of adherence.

Towards the middle of the fifteenth century, painting in

enamel had made great progress. On an unpolished plate of copper, the enameller traced with a style the outline of the figure or subject to be represented. The plate was then overlaid with a thin translucid flux, after which the enameller began to apply the colors. The outlines of the drawing traced by the style were first covered over with a dark-colored enamel, which was to give the outline upon the surface of the picture; the draperies, the sky, the background and accessories, were then expressed by enamel colors in tolerably thick layers, filling up the interstices formed by the dark-colored outline which enclosed the different enamel colors, performing as it were the same office as the lines of metal in the incrusted enamels. There was, therefore, a total absence of shadow in this painting, in which the first design was expressed by thickness of colors. The space for the flesh-tints was filled with a black or deep violet enamel; they were then rendered upon this ground by white enamel applied in layers more or less thin, in order to preserve the shadows, and thereby obtain a sketch very lightly in relief, of the principal bony and muscular parts of the face and the body; consequently, all the carnations in this process have a bistre or violet hue by which they may be easily recognized.

In order to produce effect in the rest of the painting, in which the shadows were entirely wanting, the light parts of the hair, of the draperies and the background, were, most frequently, indicated by touches of gold. The imitations of precious stones applied upon the mantles of saints and upon the draperies, are peculiar to this description of enamels, which are generally painted upon flat pieces of copper, rather thick, and coated with a thick enamel at the back, presenting a vitreous appearance.

In the early part of the sixteenth century a great change was made in the processes employed by the enamel painters. They added an enamel ground to the plate of copper before beginning the painting, and the colors, thus rendered capable of being worked with freedom and at different times, became susceptible of every kind of combination and of every degradation of tint resulting from their fusion. The drawing and painting were also rendered more perfect from its being easy to retouch them.

This led to the employment of enamel almost exclusively for the representation of sacred subjects, from the works of Raffaelle and other great Italian artists, as well as those of the German school.

From about the middle of the sixteenth century the enamellers no longer confined themselves to the production of small pictures; they created a new style of metal work. Basins, ewers, cups, plates, vases, and utensils of every kind, formed of thin sheets of copper, and most elegant in design, were overlaid with their rich and brilliant paintings. This cup is of agate, supported on a silver stem with enamelled clusters of grapes. It is of French workmanship of the present day, and is exceedingly light and graceful in its form.

In 1632, a goldsmith of Châteaudun, who was very skilful in the art of employing translucid enamels, succeeded in discovering a set of vitrifiable colors, which, when laid upon a thin ground of monochromatic enamel, to which a plate of gold served as excipient, vitrified in the fire without any change in their tints. In the use of these opaque colors, it was no longer needful for the production of the shadows, to have recourse to the black enamel paste, employed by the Limousin enamellers. The opaque colors of Toutin, the discoverer of the process, were applied upon the enamel ground, in the same manner that water colors are laid upon vellum or ivory in miniature painting.

To make a plate for an artist to paint on in enamel, a piece of gold or copper, of the requisite dimensions, and varying from one-eighteenth to one-sixteenth of an inch in thickness, is chosen. It is covered with pulverized enamel and passed through the fire, until it becomes of a bright white heat; another coat of enamel is then added, and the plate again fired; afterwards a thin layer of a substance called flux is laid upon the surface of the enamel, and the plate undergoes the action of heat for the third time. It is now ready for the painter to commence his picture upon.

Flux partakes of the nature of glass and enamel; it is semi-transparent, and liquefies more easily in the furnace than enamel. When flux is spread over a plate it imparts to it a brilliant surface, and renders it capable of receiving the colors. Every color, during the process, is mixed with a small quantity of flux; thus, when the picture is fired, the flux of the plate unites with the flux

of the color, and the coloring pigment is entirely excluded from the air, by being surrounded by a dense vitrified mass. From this will be understood the indelible nature of enamels.

The colors, as already stated, are prepared from metallic oxides. Many metals are perfectly useless to the enameller, on account of the high degree of heat to which the enamel is subjected, and his scale of color is consequently limited. Modern science has, however, done much to supply the deficiency. The colors are mixed with spike oil of lavender and spirits of turpentine, and these are chosen in preference to linseed oil or magilp (a compound of oil and varnish), because the former volatilizes rapidly under the effect of heat, while the latter, from their unctuous nature, would cause the enamel to blister. Camel-hair or sable pencils are used by the artist, and the plate undergoes the process of firing after each layer of color is spread over the whole surface. Sometimes a highly finished drawing requires fifteen or twenty firings. Great care must be taken to paint without errors of any kind, as the colors cannot be painted out or taken off, after they have once been vitrified, without incurring excesssive trouble and loss of time. If the unfortunate artist miscalculates the effect of the fire on his pigments, his only alternative is to grind out the tainted spot with pounded flint and an agate muller, and so hard is the surface, that a whole day will probably be occupied in rubbing down a square inch.

An enamel painting of an extraordinary size was executed at Berlin a few years ago. It is now in the castle church at Wittenberg, and is four and a half feet high by eight feet long. The subject is Christ on the cross; and at his feet on the right stands Luther, holding an open Bible and looking up at the Saviour, and on the left stands Melancthon, the faithful co-operator of the great reformer.

Enamelling is now seldom resorted to except for the purpose of adding to the beauty of small and choice articles of jewelry, watch and locket cases, porcelain (which style will be described under that head), and articles intended for the toilet, of which we give a sample in the form of a beautiful little vase of silver, ornamented with enamels, and the work of M. Rudolphi, of Paris.

CHAPTER X.

THE ELECTROTYPE PROCESS.

WHEN Galvani was convulsing frogs with his rude primitive battery, or when Volta was presenting to the French Academy an account of his more advanced arrangements and results, there was but slender promise of such magnificent fruits as are now seen in the electrotype process, and in the magnetic telegraph. The twilight dawn of great discoveries, like the remote sources of mighty rivers, foreshadows to common perceptions nothing of the future greatness which their full career is to embody. That subtle agency, which Volta expounded, in imperfect phrase, before the French Academy, is now known to be as wide as creation in its workings, and as intangible as the spirit of man in its substance. Already have electric currents, in their widely-varied functions, been found to pervade nearly all of material nature, and the history of electrical science has grown voluminous and absorbing beyond all precedent; though we are still constrained to believe ourselves only on the verge of this expanding realm of fact. Our present business is with this current as a worker, in a particular limited field, where it serves as a delicate-fingered artist in metals, or wears the guise of a transcendental Tubal-Cain: for such is the function of dynamic electricity in its electrotype uses. The discussion of electric metallurgy, in its wide and rapidly enlarging extent, would so much exceed our limits, that we must rest content with treating the electrotype

proper, or the process of reproducing metal plates by molecular deposition, through the regulated action of galvanic currents.

The electrotype renewal of engraved plates with perfect correctness of detail, has now become a process of as entire certainty as any of the coarser forms of casting, for all sizes and descriptions of work engraved on copper. The finest touches of the graver can be indefinitely multiplied without any loss of delicacy, and in a very short time. No mechanical impediment now prevents the unlimited reproduction of copies from the largest and finest copper-plates ever engraved, and this at a cost, which, compared with the usual prices of such prints, is absolutely trifling. One cannot but long to see this process applied to those elaborate plates, the prints from which have been sold for prices up to fifty dollars, or more, under the conviction that only a few impressions could be obtained without re-engraving, thus making the cost of a single impression about equal to the expense of making an electrotype copy of the original copper-plate. The time apparently is near at hand, when fine engravings of this description will receive so wide a diffusion as to make the original outlay for engraving a mere trifle, when distributed among the great number of copies which a low price will cause to be sold. Some publisher who is an art philanthropist, and sagacious withal, will ere long extend the principle of cheap publication into this higher department of art; thus making a portfolio of engravings by the best masters a luxury within the means of thousands, who are now excluded from their purchase by the alarming prices of good line engravings. The finest works of art can be electrotyped with the same ease as the coarsest map plate; nor is the cost of printing and paper very much increased by the fine quality of the subject, or by its delicacy of treatment.

The electrotype process was made a practical fact by Jacobi and Spencer, in 1838, though an instance of electro-metallic deposit is recorded so long ago as 1805, which, however, lay quite fruitless. Its rapid strides in improvement up to the present time, have been due to the united labors of many intelligent practitioners of its several forms of application. Ohm's law, and Smee's laws of current actions, have given fundamental principles

for reasoning and experiment, which have guided investigators in their operations, directly to positive and excellent results.

But here we should pause, before entering upon a description of the electrotype process, and the manner of preparing plated goods for the market by its aid, as now practised, to dwell for a moment on the old process of plating, which has been rapidly superseded.

The art of covering baser metals with a thin plate of silver, either for use or ornament, is said to have been invented by a spur-maker. Till then, the more elegant spurs in common use were made of solid silver, and from the flexibility of that metal, they were liable to be bent into inconvenient forms by the slightest accident. To remedy this defect, a workman at Birmingham contrived to make the branches of a pair of spurs hollow, and to fill that hollow with a slender rod of steel. Finding this a great improvement, and desirous to add cheapness to utility, he contrived to make the hollow larger, and of course the iron thicker, till at last he so coated the iron spur with silver as to make it equally elegant with those made wholly of that metal. The invention was quickly applied to other purposes.

Little more than a hundred years ago, an ingenious mechanic, named Thomas Bolsover, while employed in Sheffield in repairing the handle of a knife, composed partly of silver and partly of copper, was, by the accidental fusion of the two metals, struck by the possibility of uniting them so as to form a cheap substance, which should present only an exterior of silver, and which might therefore be used in the manufacture of various articles in which silver had before been wholly employed. He consequently began a manufacture of articles made of copper, plated with silver, but confined himself to buttons, snuff-boxes, and other light and small articles. Like many other inventors, he probably did not see the full value of his discovery, and it was reserved for another member of the Corporation of Cutlers of Sheffield, to show to what other uses copper, plated with silver, might be employed, and how successfully it was possible to imitate the finest and most richly embossed plate. He employed it in the manufacture of waiters, urns, tea-pots, candle-sticks, and most of the old decora-

tions of the sideboard, which, previously to his time, had been made solely of wrought silver. The importance of the discovery now began to be fully understood; various companies were formed; the streams in the neighborhood furnished a powerful agent for rolling out the metals in mills erected for the purpose, and workmen were easily procured from among the ingenious mechanics of Sheffield, who, in a few years, aided by proper instruction, soon equalled in the elegance of their designs and the splendor of their ornaments the most costly articles of solid silver.

One of the old ways of plating inferior metals, employed by the best workmen, was as follows: The article, after being filed and smoothed, was wrapped all over with a fillet of sheet silver, which was fastened with small wires, after which, borax, ground with water, was laid upon the surface and sprinkled with silver solder; it was then heated red hot, so as to braze the silver to the article, after which the surface was filed smooth, burnished, and otherwise got up as silver. A more common way is as follows. The piece is, in the first place, filed all over the surface, so as to be perfectly clean and bright, it is then tinned in the usual manner, by dipping it into a vessel of melted tin, and wiped over with hurds, so that not more than a very slight coating may remain. A foil of silver, beaten very thin, is then cut of the size of the article, and folded upon it as perfectly and closely as possible. In the flat parts it is beaten close, with a small hammer, and covered with cloth, while upon the mouldings and in the hollows, the foil is rubbed down with a sort of burnisher. When the silver film has been properly closed upon the article, in every part, so as to adhere to it, as it will do, from contact, a soldering bit, very similar to those used by tin-plate workers, is passed over every part of the surface, by which operation the tin and silver are united, and the pellicle of precious metal adheres to the body of the article with considerable tenacity. To make the attachment still more perfect, the surface is sprinkled with powdered rosin, and heated, the article being frequently withdrawn, and dipped into the powdered rosin, in order to flux the tin. The polishing is then effected by means of buffs of buckskin and rottenstone.

The following is the method of preparing the metal for the

flatting mill. A piece of copper, somewhat in the form of a brick, and generally about twelve inches long, three inches wide, and one and a half thick, is prepared, either by cutting it from a bar of that substance of pure copper, or by casting it in an ingot mould, as an alloy of about two pounds of brass to twelve pounds of copper. The mass, in either case, is neatly trimmed, after which it is well and exactly filed on one side with a rasp, until it is bright and level, care being taken not to allow any particle of dirt to get upon it, nor even to touch it with the fingers so as to tarnish it. When it has been thus cleaned, a plate of silver, a little less than the surface of the copper, after being made perfectly flat, is scraped with a tool, until quite clean on one side, particular care being taken not to soil it with the fingers. This plate (which is in proportion to the upper in substance, corresponds to the amount of silver which the sheet of metal is intended ultimately to bear, which is always slight,) is then laid upon the piece of copper, so that the bright surfaces of the metals are in contact. Over the silver is placed a piece of sheet-iron, of the same size, brushed over with whiting, to prevent it from adhering to the mass when heated. The three substances, thus arranged, are well secured by means of small iron binding-wires, wrapped round at intervals of an inch, and tightened by twisting with pliers. A little borax, ground with water, is laid around the silver, in the space where the edge approaches that of the copper, after which it is ready for the fire.

A small reverberatory furnace, or low, fire-brick oven, is used by the plater. When the roof of the oven is entirely red hot, the prepared metals are introduced, upon the prongs of a sort of fire-fork, and placed upon the coke at the bottom. The door in front is closed, and the draught increased, until the mass becomes red hot; in a short time afterwards the edge of the silver, where the borax was laid on, and where it acts as a flux, exhibits a slight degree of fusion, the whole of the superficial plate being nearly in the same state. The ingot must now, by the introduction of the iron fork, above mentioned, be carefully withdrawn and laid aside to cool. Upon an exact attention to this operation the chief success of the plater depends, for if the metal be not re-

moved almost immediately after the indication of fusion appears at the edge of the silver, it will presently run off into the fire: and if the removal of it, on the other hand, takes place a little too soon, the two surfaces will be only partially united, and the work, of course, be good for nothing. But when taken from the fire at that point of temperature which experience indicates, the parts of the material in contact are found to be in a state of the most perfect incorporation, so that no subsequent operation, however violent, can separate them.

Metal thus plated, is reduced into thin sheets, by passing it between steel rollers, in the usual way, taking care to heat or anneal it in the intervals of rolling. If designed for waiters, or other articles requiring great breadth, it is rolled both ways until it is spread out to the proper size, but if only for ordinary purposes, it is generally left narrow in proportion to its length. When the ingot is of about the size previously mentioned, it will be found that the copper will be overspread by the silver, to within a little space of the edge; but if the silver be very thick in proportion to the copper, it will be found, in consequence of its greater ductility, to spread beyond the inferior material.

Die sinking is the most important department in the manufacture of plated goods, and it is upon that the success and celebrity of many works of this description depend. It is, at the same time, the most expensive branch of the business; so much so, indeed, as to place the production of many articles beyond the reach of ordinary competition. The dies of the silversmith, as well as those of the brass stamper, are required to be made, for the most part, of steel, and at the same time they must be executed in a much finer manner; as, however, plated metal is very thin, and always soft, the dies are rarely hardened, notwithstanding which they will last a very long time. In stamping, when the material is very thin, or the figure deep, particular care, and the frequent repetition of gentle blows are required, especially at the beginning. The safety of the article during stamping, is likewise greatly increased by placing it between two pieces of copper of the same substance, and which are repeatedly lighted over a charcoal fire, along with the matter being stamped, and

sometimes, when the plate is very strong, it is stamped in a red-hot state.

A good deal of comparative success of a plate establishment, must depend upon the taste and spirit employed in the dies, and as fashions are constantly fluctuating, objects, to command attention, must possess as much originality as possible.

Mouldings are sometimes formed upon the edges of vessels, which are not merely ornamental, but give strength and stiffness. These are either fashioned by an instrument, called a swage, which is a grooved hammer corresponding with a rest made to fit it, and which gives the shape to the edge, after repeated blows, or by means of rollers, which is a neater and more expeditious way of arriving at the same end. There are two wheels, so placed that the groove in the upper wheel corresponds with the bead in the lower, and the piece of metal passing between these, assumes the same figure.

The greatest improvement made in this branch of manufacture, is the introduction of silver edges, beads and mouldings, instead of the plated ones, which, from their prominence, had their silver surface speedily worn off, and thus assumed a coppery look. The silver, destined to form the ornamental edgings, is laminated exceedingly thin; a square inch sometimes not weighing more than ten or twelve grains. This is too fragile to bear the action of the opposite steel dies of the swage. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, and this is the method generally employed to form these silver ornaments. The inside shell of this silver moulding is filled with soft solder, and then it is bent into the required shape, and soldered to the article for which it is intended.

The advantages offered to the plater by the electro-process are many, arising from the fact of the articles being plated *after*, instead of *before*, being manufactured. This at once entirely removed all those restrictions on taste and design, under which the plater was forced, by the nature of his process, to labor.

The following may be considered some of the principal differences existing in the two processes of plating—the old method and the electro-process:

1. The electro-plater is not limited in the use of the metal upon which he plates. There is generally used, as the basis of all electro-plated goods, a hard white metal, which possesses the sound, and approaches very nearly to the color, of silver. Inferior goods are sometimes made in brass.

2. The electro-plater is not restricted to the use of soft solder, which melts at a low temperature, and forms a very insufficient joint, besides preventing any sound or ring in the article so soldered. Where cheap goods are required, this may be used in this process as well as in the old, but is always open to the same ob jection. All goods of superior quality, made for the electro process, are soldered with what is termed in the trade *hard silver solder*, composed of two parts of silver and one part of brass melted together, which is not affected by any ordinary degree of heat, and presents a joint as strong as the metal itself.

The common solder of braziers may also be used with advantage; it is very hard and durable, and requires a strong heat to melt it.

3. The electro-plater, in producing ornamental articles, is not obliged to incur the expense of cutting iron dies for every minute portion; being under no restriction, he models his patterns, and by casting and chasing in solid metal, produces an exact copy, which is afterwards plated or gilt. Thus any pattern which can be executed in silver may be readily made in plate by this method.

4. The junction of the plating with the metal below, by the electro-process, is perfect, without the presence of any intervening substance; the forks and spoons thus made are not open to the objection of the old process, and are found to answer all the purposes of silver, in sound, appearance, and wear; they are generally tested, previously to polishing, by exposure in a furnace at a red heat.

5. From the facility with which old goods may be now restored, these goods bear an intrinsic value; whereas, before the introduction of the electro-process, a plated article worn through in any part was valueless.

Several objections have been keenly urged against the electro-process; but they may all be reduced to the following:

First objection: Deposited metal is crystalline, and therefore, though it may impart in appearance a silver coating, it must necessarily be full of minute insterstices between the crystals; hence when a metal, such as copper, is plated, it is liable to be acted upon by the atmosphere, or injured by whatever is brought into contact with it.

This objection was not without foundation, as all deposited metals are crystalline in texture, but they do not necessarily leave interstices; the objection, however, is almost entirely removed by keeping the article in motion during the deposition. By motion and proper arrangement of battery, we have deposited silver of as high specific gravity as hammered silver, which could not be the case if it were porous.*

Second objection: As only pure silver is deposited, it must necessarily be soft, and consequently liable to abrasion, and more rapid wear.

This objection is also partly true. Only pure silver can be deposited; but it is not necessarily soft: the quality of the deposit, in this respect, depends a great deal upon the nature of the solution and the battery power. Intensity of battery gives hardness to the metal deposited. There is no complaint more common amongst the burnishers of electro-plated articles, than that the metal is hard; and it is far from being an uncommon occurrence, that some goods have to be heated, so that they may be more easily burnished or polished. How far this annealing may affect the wear of the goods is not yet ascertained. That the silver is pure, Mr. Napier thinks is an advantage—hence the superior color which electro-plated goods possess; besides which, purchasers are not subject to the risk of having a plate much alloyed.

Third objection: The mounts or prominences of articles, which must have the greatest wear, have the least and thinnest deposit.

This objection is entirely without foundation, as the promi-

* James Napier, F. C. S., to whose work on Electro Metallurgy we are indebted for much practical information.

nences have always the greatest portion of deposit, and the hollow parts the least.

And here, before entering upon the details of the electro-process, let us introduce a description of the mode of copying engraved plates in the Coast Survey Office, by Mr. G. Mathiot, who has there devised many of the processes and appliances so successfully employed, and which will at once give the reader an idea of the battery and its use for the purpose of producing *fac-similes* of engraved plates, busts, medallions, statues, or other objects, of which it is often desirable to have perfect copies, at a cost considerably less than that attending the production of the original.

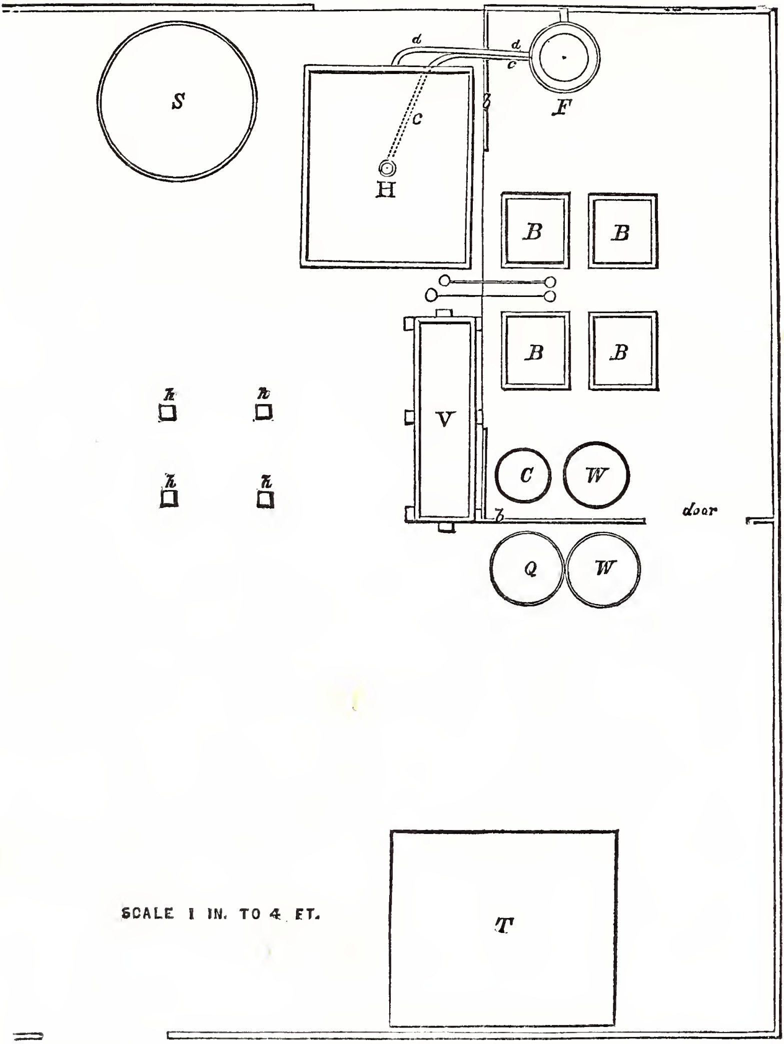
In the Coast Survey Office there are three plates, forty-two inches by thirty-eight in size, containing work of the finest quality, and which attract the attention of visitors. These are respectively an original plate, an alto or relief-lined plate, and a basso, or duplicate, so like the original as not to be easily distinguished, except by examining the back. This original, on being completed by the engravers, was carefully cleaned, and its surface silvered. It was then washed with an alcoholic solution of iodine, and exposed to the action of light; this process, one of Mr. Mathiot's invention, is, beyond question, far the best means in use for preventing a final adhesion of the deposit to the matrix plate. The plate thus prepared, was suspended vertically in a vat, containing a solution of sulphate of copper, and a raw copper-plate, of rather large size, suspended parallel to it. These plates were then made to serve as electrodes, by being connected with a powerful battery. The copper in the solution of sulphate, which adjoins the engraved face, was thus deposited by decomposition, being thrown down as a pure copper layer on the face, while the free acid acted on the raw copper-plate, and thus sustained the strength of the solution; the whole action amounting to a transfer, or carrying by water, of the copper from the rough plate to the engraved surface. When the deposition had progressed far enough to form a good surface-layer, the plate was shifted into a horizontal vat of the same solution, and the raw copper-plate supported on a frame just above it. A specially contrived furnace

sustains in this solution a heat of about 180 degrees, which greatly facilitates deposition. The current was again brought to act, and maintained in steady operation until the deposit attained the thickness requisite for safe handling. The plate and deposit were then withdrawn from the solution, filed around their common edge, and the two were then separated or split apart through the iodine layer which was introduced on the original face, forming probably an iodine atmospheric film. The deposited plate is the alto, which exhibits, in relief and direct, all the engraved reversed lines of the original. This alto was then made to serve in turn as a matrix, on which a new copper-plate, one-eighth of an inch thick, was deposited in precisely the same manner as in forming the alto. This plate is an exact duplicate of the original, and is called a basso, or an electrotype copy. It requires only a little smoothing on the back, and a removal of any accidental specks or imperfections, to be ready for the printer. The time occupied in the reproduction of a plate, containing ten square feet, can be brought within a week for forming both alto and basso, though economy of working usually makes it preferable to take somewhat more than this minimum time. A careful regulation of the current under Smee's laws is of great importance, as an indispensable means of securing the requisite metallic properties in the deposit. Planished copper-plates are quite inferior to good electrotypes for printing, as the pure metallic copper resulting from electro-deposition is free from that porosity which produces cloudiness of impression. The work of inking and wiping an electrotype is considerably less than for a planished plate, and the wear for each impression is consequently less. The first electrotype copy of the largest plate exhibited, printed about two thousand impressions, without showing wear, though the work is remarkably light and fine, so that the original would probably have failed in less than one thousand printings. The cost of producing these large plates may be judged from the rate of deposit, which is sometimes as high as 3 lbs. per square foot, in twenty-four hours. The consumption of materials admits of accurate estimate, but the cost of work, apparatus, &c., varies much with the kind and quantity of work to be done; though a

dollar per pound would probably prove a remunerating price in regular work, free from piecing or inserting. Smee estimates at a sovereign per pound, but this rate is certainly much above what the methods of Mr. Mathiot would require. This process of reproduction is made to serve as a means of inserting views, uniting separately engraved plates, so as to shorten the time of engraving, and also to facilitate erasures, by scraping off from an alto the relief-lines to be erased, and then obtaining a basso, blank in those parts. Thus the scarring and beating up from the back, which make ordinary copper-plate erasing so troublesome, are quite avoided.

A critical examination of the Coast Survey plates, will show that they are as perfect as copper-plates seem capable of being made. A comparison of these with the Southampton plates, will show a marked superiority in their evenness of deposition, and in the smoothness of their backs. The Ordnance Survey plates required to be laboriously filed all over their backs, while the inequalities filed from the backs of the Coast Survey plates were comparatively insignificant, though these plates quite exceed the English in size and thickness. Indeed, the results indicate a decidedly better management of the currents by Mr. Mathiot, than is displayed in any other electrotype work exhibited. In Elkington's electro-castings there is a degree of interior roughness, which, making all due allowance for the irregular forms of his subjects, indicates a much less perfect control of the deposit than is exhibited in the Coast Survey plates. So far as we have the means of knowing, these plates exhibit the electrotype art in its highest attained perfection. As the French Government is about borrowing the Southampton arrangements for a laboratory, connected with their *Dépôt de la guerre*, under the impression of its superiority to all European establishments of this nature, we may conclude that the Coast Survey Laboratory, excelling that of Southampton, as it clearly does, both in the facility and the results of its operations, stands absolutely at the head of electrotype practice in reproducing plates. The use of iodine to prevent adhesion, the heating of the electrolytic solution by a constant furnace, the electro-deposited silver plates, used in the bat-

Fig. 1.



teries, and other minor improvements, wrought out by Mr. Mathiot, are quite sufficient reasons for this superiority. We quote from his Report (Am. Journal of Science, vol. xv., 2d series, 1853,

and C. Survey Report for 1851, Appendix 55) the following description of the C. S. Laboratory, apparatus and manipulations:

"Laboratory Apparatus.—Figure 1 is a plan of the Coast Survey Electrotype Laboratory. The glazed partition, *b*, *b*, *b*, *b*, with a door, *d*, separates the battery room from the general laboratory, and permits an easy inspection of the batteries, without exposure to their fumes. The laboratory floor is about six feet above the ground, and slopes inward from the sides towards the scuttle holes, *h*, *h*, *h*, *h*, arranged for discharging the waste liquids spilled upon the floor. To obviate the deleterious effects of working on a floor saturated with chemical agents, when any solutions are spilled, the floor is well flooded and brushed, the water passing off through the scuttle holes. There are four battery cells, placed as indicated, B, B, B, B. A rectangular India-rubber bag, supported by a deep wooden box, contains the battery solutions. Each cell can contain nine silver and eight zinc plates. A metallic connection unites all the zinc plates of a cell, and another one all the silver plates. Each cell can be used as an independent battery, or two, three, or four cells can be connected in consecutive or simultaneous order, or all combined into two pairs of two in consecutive or simultaneous order, or into one group of three and one of one. The position of the vertical decomposing vat is shown at V, and that of the horizontal vat at

Fig. 2.

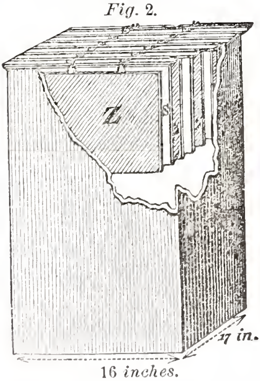
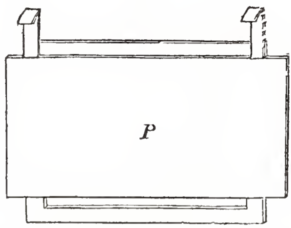


Fig. 3.

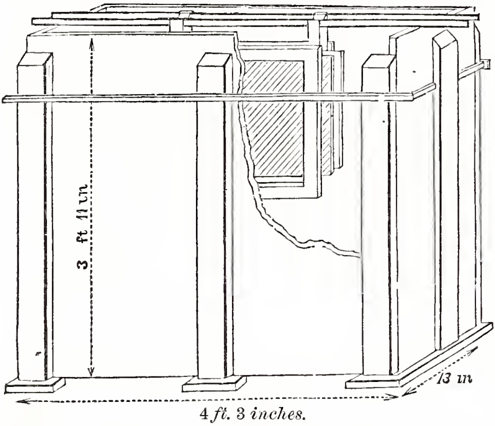


H. S is a large tub for washing plates. The tub C contains the solution of chloride of iron. Q is the quicksilver tub, and W, W, are fresh water tubs. F is the furnace, and *d*, *d*, *c*, *c*, are heating tubes connecting with the vat H. T is a flat iron table.

"Fig. 2 exhibits a cell and its included plates, with their mode of suspension.

"Fig. 3 represents the suspending frame of wood and the attached plate, P, prepared for immersion in the vertical vat.

Fig. 4.

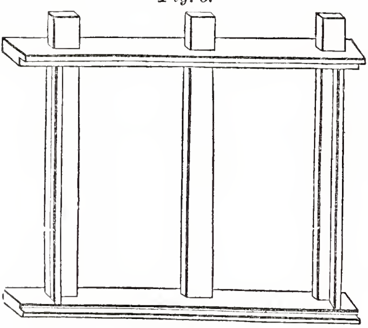


"Fig. 4 shows the vertical vat and the plates suspended in it.

"Fig. 5 represents the adjustable plate-supporting frame used in the horizontal vat.

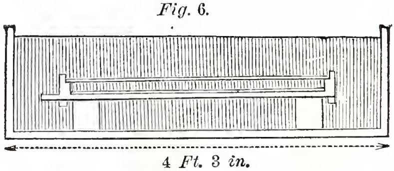
"Fig. 6 exhibits the interior arrangement of the horizontal vat, a blank plate and an engraved original being in position; also the connecting copper rods leading to the battery.

Fig. 5.



"Fig. 7 represents the heating furnace. The door for admitting air is shown at *a*, and is so connected with an adjusting compound bar of iron and zinc that

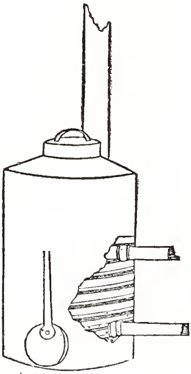
Fig. 6.



by an adjusting screw it can be arranged to regulate the draught, opening or closing the door, thus maintaining a uniform heat in the solution. After getting the fire started, this door is set so as to close when the solution reaches a heat of 180°. In principle this furnace is similar to a bath-heater. A tubular helix of lead is coiled within it like the worm of a still, and the termi-

nating branches *c* and *d* lead to the horizontal vat, the branch *c* uniting the top of the vat just below the liquid surface with the top of the coil, and *d* at the bottom of the vat with the bottom of the coil. Hence follows a circulation of the solution from the furnace at top and into it at bottom.

Fig. 7.



"MANIPULATION.—When a plate is to be electrotyped, it is placed on trestles above the open scuttle holes, *h*, *h*, *h*, *h*, and thoroughly cleaned by washing with alkalies and acids. It is then silvered, iodized, and placed before a window. A plate of rolled copper an inch larger than the engraved plate is then selected, placed on the flat iron table, and beaten with mallets until a steel straight edge shows it to be plane. It is then weighed and fixed in the vertical plate-frame by two copper hooks. The engraved plate is then similarly fixed in a similar frame, when both are placed in a vertical vat and connected with the battery.

"The process does not go on well when the plates are vertical, but it is necessary to start the castings in this position to prevent dust, motes, or specks of impurities, from settling on the face. As the rolled plate dissolves, its impurities rapidly render the solution muddy, and endanger the face of the forming plate. For common electrotypes dust or mote specks are not detrimental; but the Coast Survey copper-plates being not inferior in fineness of lines to fine steel plates, the effect of impurities settling on the face of their copies is to give the impressions a clouded appearance. On first immersing the plate, the solution should, therefore, be perfectly clean. Formerly, after each use of the vertical vat, it was emptied and washed out. When the solution had deposited its sediment, it was drawn off and strained through very fine cotton. This whole operation was extremely disagreeable, and consumed a whole day of one man.

"By a simple expedient I have saved the necessity of cleaning the vat oftener than once a month. To guard the new plate from specks and impurities, a bag of fine cotton is drawn over a slight

wooden frame, which keeps it distended. An hour or more before the solution is wanted, the bag, with its included frame, is placed on top of the solution and loaded with the copper bars used to support the plate frames. The weight causes the bag to sink gradually, filtering the contained solution as it goes down; the impurities cannot wholly choke the meshes of the cloth, as a fresh portion is constantly brought into action during the sinking. I thus filter the solution without taking it from the vat or disturbing the sediment, saving much labor, time, and annoyance.

"The plate remains in the vertical vat over night, and preparations are made in the morning to transfer it to the horizontal vat. The furnace is first brought into action. A new plate of blank copper, an inch larger than the matrix, is flattened on the iron table, and bolted to the edges of wooden bars by platinum bolts, for the purpose of preventing the plate from sagging downwards when supported horizontally. The plate so arranged is called the strapped plate. The coated matrix is then taken from the vertical vat, disengaged from its frame, and arranged in the horizontal frame. A wooden wall, an inch high, then surrounds the plate, and on this wall the strapped plate is laid, when the whole combination is placed in the horizontal vat and the connection with the battery established. The positive plate is then taken from the vertical vat and its loss of weight noted and recorded. From the known superficial area of the matrix, the quantity of copper required for a casting one-eighth of an inch thick is computed and recorded. The blank copper consumed in both vats must equal this amount before the required thickness is reached, allowance being made for impurities of rolled copper and roughness on the back of the electrotype. After a few hours of action the strapped plate becomes so loaded with impurities that they will begin to drop on the electrotype; this plate must, therefore, be removed from the vat and a new one immediately supplied. The dirty plate is then washed in the large water tub, and when cleaned its loss of weight is found and recorded. By the amount of loss the action of the batteries is tested, and it is found, if Smee's laws are being observed. Vigi-

lance must now be exercised in watching the batteries and rate of work, and the power must be varied to suit circumstances.

"The entire working battery generally requires renewal once a day, the process being conducted as follows: One zinc and one silver plate are taken from the battery; the silver placed in the solution of chloride of iron, and the zinc taken to the water tub outside the door of the battery room, where it is scrubbed clean with a hard brush. It is then reamalagated at the quick-silver tub, and taken back to the battery. The silver plate is transferred from the chloride of iron solution to the adjacent fresh water tub. Another plate is then transferred from the battery to the chloride solution, and another zinc cleaned, washed, and put back in the battery with the first silver. In this manner the whole battery can be renewed without sensibly interrupting its action.

"When the loss of weight from the rolled copper in both vats indicates that the required thickness of electrotype is gained, the plate is withdrawn from the battery, detached from its frame, its back smoothed, and its edges filed, until a separation can be made. By separation, the original becomes liberated, and the alto or reversed relief is silvered and electrotyped exactly as an original. The copy from it, or the electrotyped basso, will, if the process has been properly conducted, be a perfect fac-simile of the original, and in hardness, ductility, and elasticity, will equal the best rolled and hammered, or planished copper-plate."

It will be observed, that it is found necessary to wash the plate with an alcoholic solution of iodine, to prevent a final adhesion of the deposit to the matrix plate: but when less delicacy is required, and there are no minute lines, like those that go to make up an engraved plate, and which are in danger of being filled up unless treated in the most careful manner; the same results may be obtained by moistening the surface with sweet oil, applied by a camel-hair pencil, and then cleaned off by passing a silk cloth over it; or, instead of oil, the surface may be brushed over with black lead, which will impart to it a bronze appearance

It should also be remarked, that no particular form of apparatus is required for electrotyping, but certain modifications may

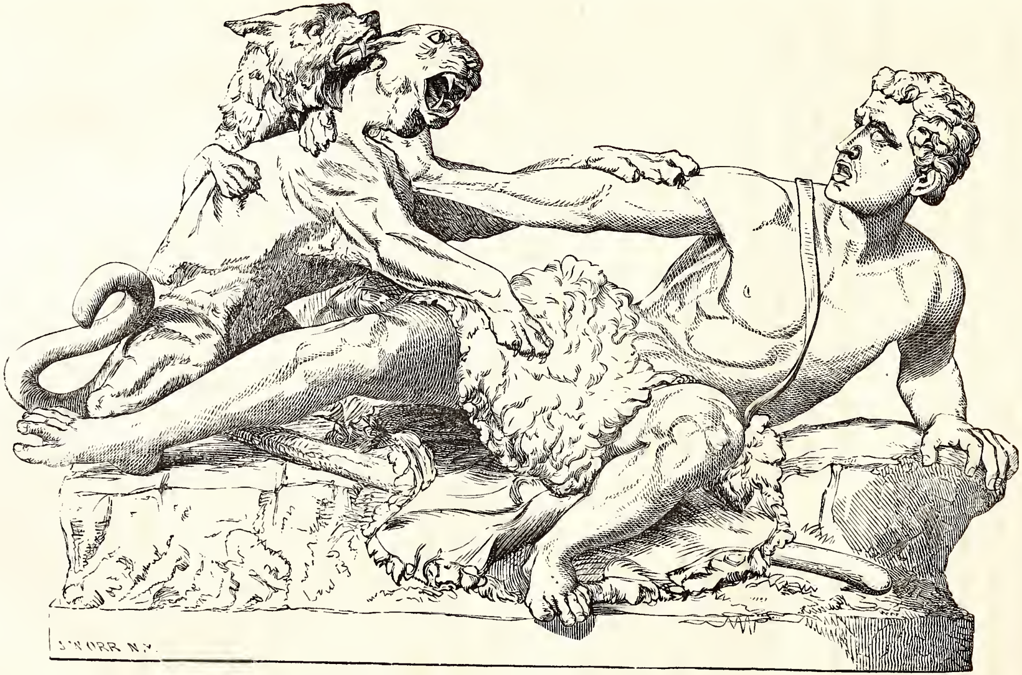
8*

be adopted for convenience and economy. As every portion of the zinc in the acid is capable of giving electricity, by placing the cell that contains the zinc in the centre of the copper solution, moulds may be suspended on each side of that cell. The zinc plates should not be allowed to touch the cell, as the copper will be reduced upon it and the cell destroyed. To avoid this, the zinc may be suspended by a small wooden peg, put through it, and made to rest upon the edge of the cell.

The directions given for obtaining a mould from an engraved plate, by deposition, are applicable to taking moulds from any metallic medal, engraving or figure, that is not undercut; and for depositing within the moulds so produced. On the first discovery of this art, the electrotypist was confined to metallic moulds, as the deposition would not take place except upon metallic surfaces; but the discovery that polished plumbago, or black lead, had a conducting power similar to that of metal, and that the deposit would take place upon its surface with nearly the same facility as upon metal, freed the art at once from many trammels, and enabled the operator to deposit upon any substance—wood, plaster-of-Paris, wax, &c.—by brushing over the surface with black lead. The substances used for taking moulds from objects to be copied by electrotype, are beeswax, stearine, plaster-of-Paris, and fusible metal; recently gutta percha has been very successfully used.

If a model or figure be composed of plaster-of-Paris, a mould is often taken in copper by deposition; the figure is saturated with wax, and copper deposited upon its surface sufficiently thick to bear handling without damage, when taken from the model. The figure with the copper deposit is carefully sawn in two, and then boiled in water, by which the plaster is softened, and easily separated from the copper, which, in turn, serves as a mould, in which the deposit is to be made. When the deposit is made sufficiently thick, the copper mould is peeled off, and the two halves of the figure soldered together.

Busts and figures, and other complicated works of art, which cannot be perfectly coated with black lead, may be covered with a film of silver or gold, which serves as a conducting medium for



SHEPHERD ATTACKED BY A LEOPARD (ZINC CASTING.)

p. 179.

the copper. This is effected by a solution of phosphorus in sulphuret of carbon.

It is often found necessary to coat metals easily acted upon by the atmosphere, with those that are less sensitive, and will not, therefore, corrode as rapidly. An instance of this is given at page 46, in the form of an iron baptismal font, from the Berlin foundry, and which is covered with a thin coat of copper. To effect this, the article is first steeped in hot caustic potash or soda, to remove any grease or oil. Being washed from that, it is placed for a short time in dilute sulphuric acid, consisting of about one part of acid to sixteen parts of water, which removes any oxide that may exist. It is then washed in water, and scoured with sand till the surface is perfectly clean, and finally attached to the battery, and immersed in a cyanide solution. All this must be done with dispatch, so as to prevent the iron from combining with oxygen. An immersion of five minutes' duration, in the cyanide solution, is sufficient to deposit upon the iron a film of copper. But it is necessary to the complete protection of the iron, that it should have quite a thick coating; and, as the cyanide process is expensive, it is preferable, when the iron has received a film of copper by the cyanide solution, to take it out, wash it in water, and attach it to a single cell, or weak battery, and put it into a solution of sulphate of copper.

In covering iron with zinc, the precaution necessary with copper is not required; zinc being the positive metal, acids have a stronger affinity for it than for iron, and, therefore, an acid solution may be used. Zinc may also be deposited upon black lead surfaces in the same manner as copper; but, unless more than ordinary precautions are observed, an article formed in this manner is so brittle that it can hardly be handled without breaking, from its crystalline character.

Statues are frequently cast in zinc. The castings come from the mould in so pure and finished a state that they require very little subsequent chasing, and their cost is only about one-sixth that of bronze, which they are made to resemble, by means of the electrotype process.

The group here presented is of this character. It represents

a shepherd attacked by a leopard. This is one of the zinc castings for which the foundry of Mr. Geiss, of Berlin, has become celebrated. The application of zinc to monumental statuary was a discovery of Geiss, and has been carried by him to perfection. Its entire success as a rival and substitute of bronze casting is shown in this group, and still more in the noble work of Kiss—"The Amazon"—an engraving of which we have already given at page 94.

Silver may be deposited upon any metal, but not upon all with equal facility. Copper, brass, and German silver are the best metals to plate; iron, zinc, tin, pewter, and Britannia metal are much more difficult; lead is easier, but it is not a good metal, because of the rapidity with which it tarnishes, and from its softness easily yields to the pressure of the burnisher; nevertheless, all these alloys may be, and are, plated, but cannot give the satisfaction which brass, copper, or German silver afford.

This process is known as electro-plating, which also embraces that of gilding. The solution of silver used for plating consists of cyanide of silver dissolved in cyanide of potassium, which may be prepared in various ways. But the best and cheapest method of making up the silver solution is by the battery, which saves all expense of acids and the labor of precipitation. The following directions are given for preparing a solution which is intended to have an ounce of silver to the gallon:

Dissolve one hundred and twenty-three ounces of cyanide of potassium in one hundred gallons of water; get one or two flat porous vessels, and place them in this solution to within half an inch of the mouth, and fill them to the same height with the solution; in these porous vessels place small plates or sheets of iron or copper, and connect them with the zinc terminal of the battery; in the large solution place a sheet or sheets of silver connected with the copper terminal of the battery. This arrangement being made at night, and the power employed being two of Wollaston's batteries, of five pairs of plates, the zinc seven inches square, it will be found, in the morning, that there will be dissolved from sixty to eighty ounces of silver from the sheets. The solution is now ready for use; and, by observing that the

EPERGNE (ELECTROPLATED). p. 181.

articles to be plated have less surface than the silver plate, forming the positive electrode, for the first two days, the solution will then have the proper quantity of silver in it.

Napier says the amateur electrotypist may, from this description, make up a small quantity of solution for silvering his medals or figures; for example, a half ounce of silver to the gallon of solution will do very well; a small quantity may be prepared in little more than an hour.

To illustrate the process of electro-plating, we have selected an epergne. The design is a beautiful female, supporting a cornucopia, from which rises a basket of intertwining vines and grapes. The body is composed of German silver, which must be boiled in an alkaline lye, to free it from grease, then washed from the lye, and dipped into dilute nitric acid, which removes any oxide that may be formed upon the surface; it is afterwards brushed over with a hard brush and sand. The alkaline lye should be in a caustic state, which is easily effected by boiling the carbonated alkali with slacked lime, until, on the addition of a little acid to a small drop of the solution, no effervescence occurs. The lime is then allowed to settle, and the clear liquor is fit for use. The lye should have about half a pound of soda-ash, or pearlash, to the gallon of water. The nitric acid, into which the article is dipped, may be diluted to such an extent that it will merely act upon the metal. Any old acid will do for this purpose. In large factories the acid used for dipping before plating is generally afterwards employed for the above purpose of cleaning.

The article, now thoroughly cleaned and dried, has a copper wire attached to it, either by twisting it round the article or putting it through an open part of it, to maintain it in suspension. It is then dipped into nitric acid as quickly as possible, and washed through water, and then immersed in the silver solution, suspending it by the wire which crosses the mouth of the vessel from the zinc of the battery. The nitric acid generally used and found best for dipping is of the specific gravity, 1.518, and contains ten per cent. sulphuric acid. The article is instantly coated with silver, and ought to be taken out after a few seconds, and well brushed. On a large scale, brushes of brass wire attached to a

lathe are used for this purpose; but a hard hair-brush with a little fine sand will do for small works. This brushing is used in case any particles of foreign matter may be still on the surface. It is then replaced in the solution, and in the course of a few hours a coating of the thickness of tissue paper is deposited on it, having the beautiful matted appearance of dead silver. If it is desired to preserve the surface in this condition, the object must be taken out (without touching it with the hands) and immersed in boiling distilled water for a few moments. On being withdrawn, sufficient heat has been imparted to the metal to dry it instantly. It must then be placed under a glass shade, as a very few days' exposure to the air tarnishes it, by the formation of a sulphuret of silver, and that more especially in a room where there is fire or gas. If the article is not wanted to have a dead surface, it is brushed with a wire brush, and old ale or beer, but the amateur may use a hard brush and whiting. It may be afterwards burnished, by rubbing the surface with considerable pressure, with polished steel or the mineral termed blood stone.

In depositing silver from the solution, a weak battery may be used; though when the battery is weak the silver deposited is soft, but if used as strong as the solution will allow, say eight or nine pairs, the silver will be equal in hardness to rolled or hammered silver. If the battery is stronger than the solution will stand, or if the article is very small compared to the size of the plate of silver forming the positive electrode, the silver will be deposited as a powder. Gas should never be seen escaping from either pole; the surface of the article should always correspond as nearly as possible with the surface of the positive electrode, otherwise the deposit runs the risk of not being good; it requires more care, and the solution is apt to be altered in strength.

In plating large articles (such as those plated in factories) it is not always sufficient to dip them in nitric acid, wash and immerse them in the solution, in order to effect a perfect adhesion of the two metals. To secure this, a small portion of quicksilver is dissolved in nitric acid, and a little of this solution is added to water, in sufficient quantity to enable it to give a white silvery tint to a piece of copper when dipped into it; the article then, whether

made of copper, brass, or German silver, is, after being dipped in the nitric acid and washed, dipped into the nitrate of mercury solution till the surface is white; it is then well washed, by plunging it into two separate vessels containing clean water, and finally put into the plating solution. This secures perfect adhesion of the metals. One ounce of quicksilver thus dissolved will do for a long time, though the liquor is used every day. When the mercury in this solution is exhausted, it is liable to turn the article black upon being dipped into it; this must be avoided, as it also causes the deposited metal to strip off.

When articles are taken out of the solution, washed and dried, their color is chalk-white. They are generally weighed before being scratch-brushed. Although this operation does not displace any of the silver, still, in taking off the chalky appearance, there is a slight loss of weight. The appearance after scratching is that of bright metallic silver. A little sulphuret of carbon added to the plating solution prevents the chalky appearance, and gives the deposit the appearance of metallic silver. Any thickness of silver may be given to a plate by continuing the operation a proper length of time. One ounce and a quarter to one ounce and a half of silver, to the square foot of surface, will give an excellent plate about the thickness of ordinary writing-paper.

The perfect smoothness which a medal generally possesses on the surface, renders it very difficult to obtain a coating of dead silver upon it, having the beautiful silky lustre which characterizes that kind of work, except by giving it a very thick coating of silver, which takes away the sharpness of the impression. This dead appearance can be easily obtained by putting the medal, previous to silvering, in a solution of copper, and depositing upon it, by means of a weak current, a mere blush of copper, which gives the face of the medal that beautiful crystalline richness that deposited copper is known to give. The metal is then to be washed from the copper solution, and immediately to be put into the silver solution. A very slight coating of silver will suffice to give the dead frosty lustre so much admired, and in general so difficult to obtain.

Messrs. Elkinton & Co., of Birmingham and London, have been the most successful in developing the electrotype process and in bringing it to its present high position. In 1840 they took out a patent for the process both in England and France. This firm now employs about five hundred workmen at Birmingham, executing the designs of some of the best artists of the day. About thirty other English manufacturers are licensed to use the process. And while we have new and beautiful creations of art thus placed within our reach at comparatively small cost, the finest specimens of the antique and the choice productions of the middle ages are, by the same means, placed before us with all the force and beauty of the originals. We have here a specimen executed by Messrs. Elkinton, made for the Queen, from the original in the Hôtel de Cluny, by Francois Briot.

We give only the stand, which is designed to support the ewer made by the same hand, and which is decorated in the same exquisite manner. These are in pewter. It is probable that the original, executed in wax, had been reproduced in silver for some prince or nobleman, and carved by Briot. It was by means of a mould taken from this prototype that numbers of pewter casts were produced, similar to the one we have had occasion to refer to.

The decorations of the stand (which we give on a small scale) are more remarkable than those of the ewer, the artist having lavished on it all the resources of his art, and all the riches of his imagination.

The predominant idea represented here is, that temperance is necessary to the man who wishes to excel in the arts and sciences; the figure of this virtue is, therefore, represented in the centre of the stand, on that part which the artistic world dignifies by the name of *umbilic*, and which is intended to receive the foot of the ewer.

We read the word "Temperantia" round the principal subject, which consists of a woman seated in the midst of a pleasant landscape, holding a ewer in one hand and a goblet in the other; the accessories which surround it, are all ingenious allegories, and all of which allude to the benefits derived from water; they

SIDE-BOARD DISH—ELECTROTYPED FROM ORIGINAL IN THE LOUVRE.

p. 184.

are the sickle, the symbol of harvest; the trident of Neptune; the caduceus of Peace; and the torch of Love broken by Temperance. Around the *umbilic* are the four elements in elegant cartouches, separated by caryatides. Air is represented by Mercury; water, by the nymph of a river; the earth, by a beautiful woman in a recumbent position, and holding ears of corn in her hand; and fire by Mars, seated and holding thunderbolts in one hand, and a sword in the other. The rim of the stand is occupied by eight cartouches, separated by fanciful devices, mingled with allegories.

Silver may be deposited from its cyanide solution upon wax moulds polished with black lead, almost as easily as copper, but for this purpose it is better to have the solution much stronger than for plating. Eight ounces of silver to the gallon of solution make a very good strength. Nevertheless, no articles are made in silver by depositing upon wax in this manner. Strong solutions of cyanide of potassium and silver act upon wax, and would soon destroy a mould. The method of making articles in solid silver by the electro-process is as follows: A copper mould is made by the electrotype, and the silver is deposited within this mould to the proper thickness; after which it is kept in a hot solution of crocus and muriatic acid, or boiled in dilute hydrochloric acid, which dissolves the copper without injuring the silver.

Copper moulds intended for receiving a deposit must be protected on the back; but if the solution is very strong, there is every danger that it will decompose the protecting substance, thus rendering the solution very dirty, and causing a sediment. For the purpose of protecting the moulds, various suggestions and experiments have been made; amongst other substances, pitch has been tried; it is easily effected alone, but on boiling a little of it in potash, a heavy and dirty sediment is left, destitute of any adhesive property; on putting a quantity of this sediment into a pot nearly filled with melted pitch, a violent effervescence will take place, setting free a volume of white fumes having a creosotic smell. After all effervescence has ceased, which will not be before a considerable time, and when all the mass seems to have been acted upon, the process of making an excellent protecting

coating is complete—a coating which will not yield in the solution, and which is at once good and cheap, its only fault being its brittleness.

The illustration here given, of electrotyping in solid silver—the Iliad Salver, representing the prayer of Thetis to Jupiter, with scenes from Homer in the border—was executed at Birmingham, by Messrs. Elkinton & Co. "Thetis supplicating Jupiter to render the Greeks sensible of the wrongs done to Achilles," occupies the centre compartment; the four angular compartments exhibiting her attendant nymphs. The subjects in the two small circular panels, are, "Thetis consoling Achilles," and "Thetis bringing to Achilles the armor made by Vulcan." Of the bas-reliefs in the border, there are eight; the subjects of them are, "The contest between Agamemnon and Achilles;" "The Heralds conducting Briseis from the tent of Achilles;" "The Greeks driven beyond their fortifications;" "Menelaus and Meriones, assisted by the Ajaxes, bearing off the body of Patroclus to the ships;" "Achilles driving the Trojans from the intrenchments, by showing himself on the walls;" "The grief of Achilles over the body of Patroclus;" "Achilles dragging the body of Hector round the walls of Troy;" "Priam soliciting from Achilles the body of his son, Hector." These sculptured pictures—for such they are—show consummate skill in drawing. Although many of them contain numerous figures, each is perfected with rare skill, and will bear the test of the minutest scrutiny, as regards either composition or manipulation.

In the manufacture of silver articles, the electro-process has not yet been of extensive application, and in making duplicates of rare objects of art, and costly chased or engraved articles in silver, one prevailing, and, as yet, insurmountable objection has been felt, namely, they have no "ring," and seem, when laid suddenly upon a table, to be cracked or unsound, or like so much lead; this disadvantage is, no doubt, partly owing to the crystalline character of the silver, and partly to the pure character of the silver, in which state it has not a sound like standard or alloyed silver. That this latter cause is the principal one, appears from the fact, that a piece of silver thus deposited is not much

ILIAD SALVER, ELECTROTYPED.

p. 186.

improved in sound by being heated or hammered, which would destroy all crystallization. Articles made in gold by the electro-process, have the same peculiarity; but these objections have but little weight where articles are designed for ornaments.

The operation of gilding, or covering other metals with a coating of gold, is performed in the same manner as the operation of plating, with the exception of a few practical modifications. The old process, which we will here describe, is most pernicious and destructive to human life; the mercury, volatilized by the heat, insinuates itself into the bodies of the workmen, notwithstanding the greatest care; and those who are so fortunate as to escape, for a time, absolute disease, are constantly liable to salivation from its effects. Paralysis is common among them, and the average of their lives is very short—not exceeding thirty-five years, according to estimate.

The art of gilding consists in covering other bodies with a thin coat of gold, which may be done either by mechanical or chemical means. The mechanical mode is the application of gold leaf or gold powder to various surfaces, and by different means; chemical gilding, to which we here confine our attention, is the application of gold, by chemical affinity, to metallic surfaces. We have already given many illustrations of bronze gilt, and the following is the process of applying the gold, known as *wash gilding*.

After weighing the fine gold, the workman puts it in a crucible, and as soon as this becomes faintly red, he pours in the requisite quantity of mercury; which is about eight to one of gold. He stirs up this mixture with an iron rod, bent hookwise at the end, leaving the crucible on the fire till he perceives that all the gold is dissolved. He then pours the amalgam into a small earthen dish containing water, washes it with care, and squeezes out with his fingers all the running mercury that he can. The amalgam that now remains on the sloping sides of the vessel, is so pasty as to preserve the impression of the fingers. When this is squeezed in a chamois-leather bag, it gives up much more mercury, and remains an amalgam, consisting of about thirty-three of mercury, and fifty-seven of gold, in one hundred parts. The mercury which passes through the bag, under the pressure of the fingers,

holds a good deal of gold in solution, and is employed in making fresh amalgam.

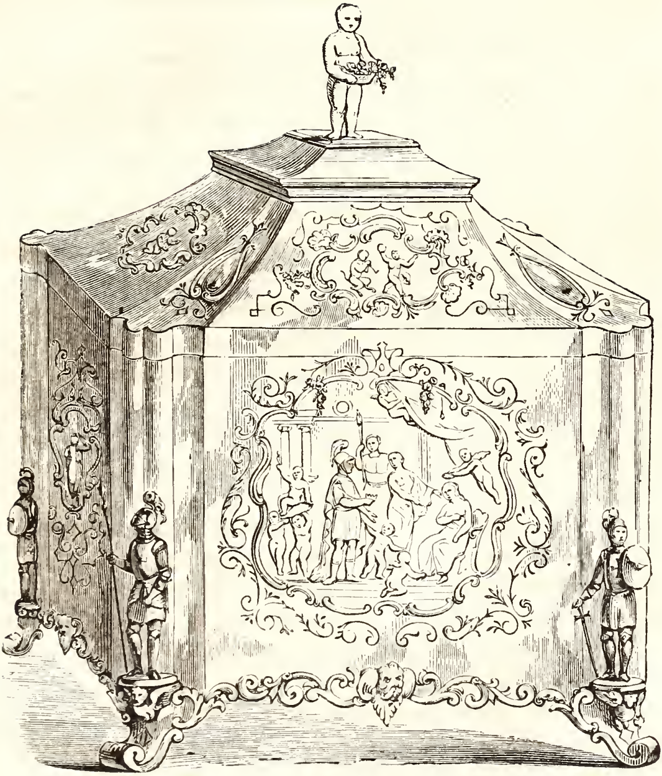
The amalgam of gold is applied to brass, through the intervention of pure nitric acid, holding in solution a little mercury. On the application of a gentle heat the mercury dissolves, with the disengagement of fumes of nitrous gas, which must be allowed to escape into the chimney.

The workman anneals the piece of bronze, after it has come out of the hands of the turner and engraver. He sets it among burning charcoal or peat, covering it quite up, so that it may be oxidized as little as possible, and taking care that the thin parts of the piece do not become hotter than the thicker. The operation is done in a dark room, and when he sees the piece of a cherry-red color, he removes the fuel from about it, lifts it out with long tongs, and sets it to cool slowly in the air.

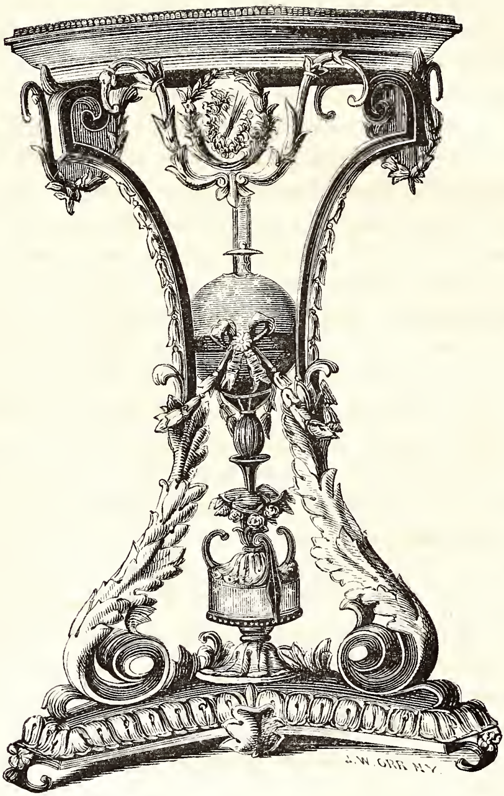
The object of this process is to clear the surface from the coat of oxide, which may have formed upon it. The piece is plunged into a bucket filled with extremely dilute sulphuric acid; it is left there long enough to allow the coat of oxide to be dissolved, or at least loosened; and it is then rubbed with a hard brush. When the piece becomes perfectly bright, it is washed and dried.

The gilder's scratch-brush, or pencil, made with fine brass wire, is to be dipped into the solution of nitrate of mercury, and is then to be drawn over a lump of gold amalgam, laid on the sloping side of an earthen vessel, after which it is to be applied to the surface of the brass. This process is to be repeated, dipping the brush into the solution, and drawing it over the amalgam, till the whole surface to be gilded is coated with its just proportion of gold. The piece is then washed in water, dried, and put to the fire, to volatilize the mercury. If one coat of gilding be insufficient, the piece is washed over anew with amalgam, and the operation re-commenced till the work prove satisfactory.

Whenever the piece is well coated with amalgam, the gilder exposes it to a glowing heat, turning it about, and heating it by degrees to the proper point; he then withdraws it from the fire, lifts it with long pincers, and seizing it in his left hand, protected by a stuffed glove, he turns it over in every direction, rubbing and



SILVER AND GILT CASKET.



TABLE—(METAL AND PORCELAIN). p. 189.

striking it all the while with a long-haired brush, in order to equalize the amalgam. He now restores the piece to the fire, and treats it in the same way, till the mercury be entirely volatilized, which he recognizes by the hissing sound of a drop of water let fall upon it. During this time he repairs the defective spots, taking care to volatilize the mercury very slowly. The piece, when thoroughly coated with gold, is washed and scrubbed well in water acidulated with vinegar.

If the piece is to have some parts dead, and others burnished, the latter are to be covered with a mixture of Spanish white, bruised sugar candy, and gum dissolved in water. When the gilder has protected the burnished points, he dries the piece, and carries the heat high enough to expel the little mercury which might still remain on it. He then plunges it, while still a little hot, in water acidulated with sulphuric acid, washes it, dries it, and gives it the burnish. This is done by rubbing the piece with burnishers of hematite (blood stone). The workman dips his burnisher in water sharpened with vinegar, and rubs the piece always in the same direction, backwards and forwards, till it exhibits a fine polish, and a complete metallic lustre. He then washes it in cold water, dries it with a fine linen cloth, and concludes the operation by drying it slowly on a grating placed above a chafing-dish of burning charcoal.

The illustration that we give, is an object worthy of great praise, for the beauty and perfection of its workmanship. It is a table, the top of which is a circular plate of porcelain, (which we shall introduce elsewhere,) exquisitely painted, and set in a gilt border. This is supported by three curved and foliated gilt stems, which rise from a metallic triangular base, and at the point of greatest contraction they sustain a globe of rich, blue porcelain, set with gilt stars.

For cold gilding, sixty grains of fine gold and twelve of rose copper are to be dissolved in two ounces of aqua regia. When the solution is completed, it is to be dropped on clean linen rags, of such bulk as to absorb the liquid. They are then dried, and burned into ashes. These ashes contain the gold in powder. When a piece is to be gilded, after subjecting it to the necessary

operations of softening or annealing, and brightening, it is rubbed with a moistened cork, dipped in the above powder, till the surface seems to be sufficiently gilded. Large works are thereafter burnished with pieces of hematite, and small ones with steel burnishers, along with soap water.

In gilding small articles, as buttons, with amalgam, a portion of this is taken, equivalent to the work to be done, and some nitrate of mercury solution is added to it in a wooden trough; the whole articles are now put in, and well worked about with a hard brush, till their surfaces are equally coated. They are then washed, dried, and put together into an iron frying-pan, and heated till the mercury begins to fly off, when they are turned out into a cap, in which they are tossed and well stirred about with a painter's brush. The operation must be repeated several times for a strong gilding. The surfaces are finally brightened by brushing them along with small beer or ale grounds.

Gilding, by the electro-process, is generally performed upon silver articles, and the method of proceeding is as follows. When the articles are cleaned, after the manner already described for plating, they are weighed, and well scratched with wire brushes, which cleanse away any tarnish from the surface, and prevents the formation of air-bubbles; they are then kept in clean water until it is convenient to immerse them in the gold solution. One immersion is then given, which merely imparts a blush of gold; they are taken out and again brushed; they are then put back into the solution, and kept there for three or four minutes, which will be sufficient, if the solution and battery are in good condition; but the length of time necessarily depends on these two conditions.

The gilding solution generally contains from one half to an ounce of gold in the gallon, but for covering small articles, such as medals, for tinging daguerreotypes, gilding rings, thimbles, &c., a weaker solution will do. The solution should be sufficient in quantity to gild the articles at once, so that it should not have to be done bit by bit; for when there is a part in the solution and a part out, there will generally be a line mark at the point touching the surface of the solution. The rapidity with which metals are

SILVER GILT COFFEE POT. p. 191.

acted upon at the surface-line of the solution, is remarkable. If the positive electrode be not wholly immersed in the solution, it will, in a short time, be cut through at the edge of the water, as if cut by a knife. This is also the case in silver, copper, and other solutions.

The best method of preparing the gold solution, is that described for silver. For all the operations of gilding by the cyanide solution, it must be heated to at least 130° Fah. After the articles are cleaned and dried, they are weighed, and, when gilt, they are weighed again; thus the quantity of gold deposited is ascertained. Any convenient means may be adopted for heating the solution. The one generally employed, is to put a stoneware-pan, containing the solution, into a vessel of water, which is kept at the boiling point. The hotter the solution, the less battery power is required; generally three or four pairs of plates are used for gilding, and the solution is kept at 130° to 150° Fah.; but one pair will answer if the solution be heated to 200°.

As the gold solution evaporates, by being hot, distilled water must, from time to time, be added; the water should always be added when the operation of gilding is over, not when it is about to be commenced, or the solution will not give so satisfactory a result. When the gilding operation is continued successively for several days, the water should be added at night.

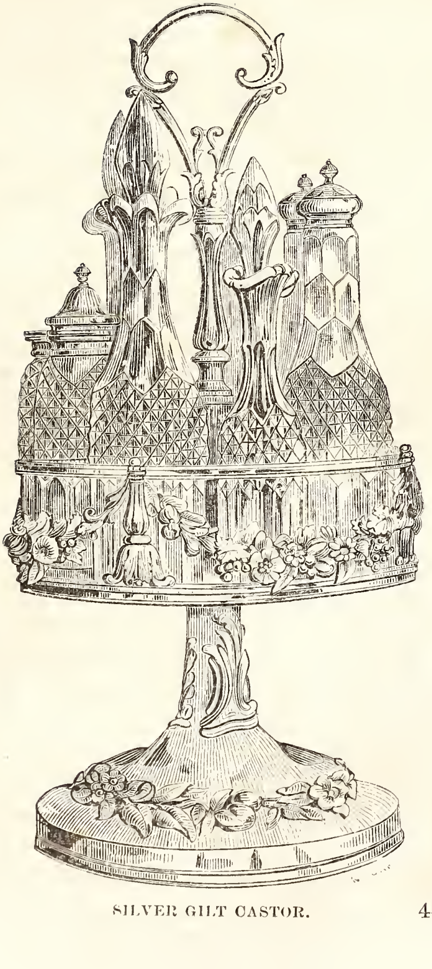
The gold upon the gilt article, on coming out of the solution, should be of a dark yellow color, approaching to brown, but this, when scratched, will yield a beautiful, rich, deep gold. If the color is blackish, it ought not to be finished, for it will never either brush or burnish a good color. If the battery is too strong, and gas is given off from the article, the color will be black; if the solution is too cold, or the battery rather weak, the gold will be light colored, so that every variety of shade may be imparted. A very rich dead-gilt may be made by adding ammoniuret of gold to the solution, just as the articles are being put in.

According to the amount of gold deposited so will be its durability: a few grains will serve to give a gold color to a very large surface, but it will not last; this proves, however, that the process may be used for the most inferior quality of gilding.

Gold thinly laid upon silver will be of a light color, because of the property of gold to transmit light. The solution for gilding silver should be made very hot, but for copper it should be made at the minimum heat. A mere blush may be sufficient for articles not subjected to wear, but on watch-cases, pencil-cases, chains, and the like, a good coating should be given. An ordinary-sized watch-case should have from twenty grains to a pennyweight; a mere coloring will be sufficient for the inside, but the outside should have as much as possible. A watch-case, thus gilt, for ordinary wear, will last five or six years without becoming base.

We have already spoken of the danger attending gilding by the old method of employing an amalgam of gold and mercury; but that of electro-gilding, if not so fatal in its effects, is also destructive of health. Mr. Napier says the hands of those engaged in gilding or plating are subjected to ulceration, particularly if they have been immersed in the solution. The ulcers are not only annoying but painful, and, on their first appearance, if care is not properly taken to wash them in strong cyanide of potassium, and then in acid water, the operator will, in a short time, have to take a few days' rest. He thus gives his own experience, and that of his companions, while employed in electro-plating and gilding, in apartments that were improperly ventilated.

"The gas has a sickening smell, and gives to the mouth a saline taste, and scarcity of saliva; the saliva secreted is frothy. The nose becomes dry and itchy, and small pimples are formed within the nostrils, which are very painful. Then follows a general languor of the body, disinclination to take food, and a want of relish. After being in this state for some time, there follows a benumbing sensation in the head, with pains, not acute, shooting along the brow; the head feels a heavy mass, without any individuality in its operations. Then there is bleeding at the nose in the morning when newly out of bed; after that comes giddiness: objects are seen flitting before the eyes, and momentary feelings as of the earth lifting up, and then leaving the feet, so as to cause a stagger. This is accompanied with feelings of terror, gloomy apprehensions, and irritability of temper. Then follows a rushing of blood to the head; the rush is felt behind



SILVER GILT CASTOR.

the ears with a kind of hissing noise, causing severe pain and blindness; this passes off in a few seconds, leaving a giddiness which lasts for several minutes." In his own case, he says: "The rushing of blood was without pain, but attended with instant blindness, and then followed with giddiness. For months afterwards a dimness remained, as if a mist intervened between us and the object looked at; it was always worse towards evening, when we grew very languid and inclined to sleep. We rose comparatively well in the morning; yet were restless, our stomach was acid, visage pale, features sharp, eyes sunk in the head, and round them dark in color; these effects were slowly developed. Our experience was nearly three years."

However gratifying the progress of electrotype art has already been, there is evidently much more to be accomplished by its agency in copying all varieties of designs in metals. Electro-stereotyping is already much in use, and must become far more common in this age of large editions. The letter-press and woodcuts of a popular magazine are now printed from a thin electro-deposited copper layer, backed with a fused metal filling. Our own country, requiring such immense issues of popular works, both of literature and of art, would seem to be the natural home of the electrotype, and we feel a well-based confidence that many perfections and amplifications will be given to this beautiful process in the country which has most to gain by the progress. The field of novel application is by no means yet exhausted, but many hitherto unimagined uses will doubtless spring up, as this art advances to greater perfection and facility. The silver gilt castor, Number 44, is of American workmanship, and was manufactured by James T. Ames, of Chicopee, Massachusetts. The ornaments are tasteful and judiciously arranged, and the bottles are of cut glass. And we close this page with a salt-cellar, from the same source. It is silver gilt, and pierced to show the rich color of the ruby glass lining. Works of this description cannot be too highly commended, and it is gratifying to know that they can be produced in this country with so much feeling for the really beautiful.

CHAPTER XI.

PORCELAIN.

THE manufacture of porcelain is known to have been carried on in China at least since A.D. 442, and it has been asserted that it dates back so far as 163 B. C. And in China the finest porcelain continues to be made. The name is said to be derived from the Portuguese, *porcelana*, "a cup," while to the French it has also been attributed, who erroneously supposed that the materials of which porcelain is composed required to be matured under ground for one hundred years—"pour cent années." But Scaliger held that it was made of sea-shells, beaten small and buried under ground for eighty or one hundred years. Porcelain is the name of this little white shell-fish, which is always found with sponges, and in parts of Asia and Africa the shells pass current as money. The Japanese have also possessed a knowledge of the art of making porcelain from a very early date, though they have never equalled the finest specimens of the Chinese manufacture.

The abundance of materials suitable for the production of pottery which lie scattered over the surface of the soil, the facility for moulding soft paste into any form whatever, solely by means of the hand, and the possibility of giving it sufficient dryness and solidity by exposure to the heat of the sun, have caused the ceramic art to be one of the first practised by mankind.

Accordingly we find it held in honor from the earliest antiquity, and the Greeks struck medals and erected statues in honor of their ceramic artists. The Etruscans, after the Greeks, made

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pottery of their own, specimens of which are found at the present day in different parts of ancient Etruria; and the Romans have left us several kinds of pottery, which differ from each other as to date, materials, and principles of fabrication. Almost all possess some interest as works of art, and they are found scattered in all countries over which the Roman Empire extended.

The process of the lustrous glazing of the Roman pottery appears to have been lost about the third century of our era, and it is probable that the invasion of the barbarians, and the wars that desolated Europe in the fourth and fifth centuries, were more fatal to the ceramic than to any other of the arts; for, excepting the Greeks, who had still preserved a degree of internal tranquillity, all nations, to date from that period, appear to have given up entirely the cultivation of the ceramic arts, or at least to have confined the application of them to very common purposes. The middle ages, in fact, have left us no artistic pottery, and no written document to lead us to suppose the existence of productions which time might have entirely destroyed. It is not, therefore, until the beginning of the fifteenth century that we find among the European nations any pottery but such as has been designed for the commonest domestic use, and none that art has been pleased to decorate.

Spain takes precedence of Italy in the manufacture of enamelled earthenware, and there is a tradition in the latter country that their processes for the manufacture of earthenware were imported into that country by Arabian or Spanish workmen, from the Balearic islands.

Pottery overlaid with a colored varnish was used in the decoration of buildings in the fourteenth century. And this opaque varnish continued to improve until towards 1450, when Luca della Robbia, after numerous attempts, succeeded in giving to his sculpture in clay the brilliancy and durability of marble, by glazing them with a white enamel, opaque, very hard, and without cracks. The fame of these works spread all over Europe, and in a short time he found himself unable to execute the orders that poured in upon him, and he therefore invited his two brothers, also sculptors, to share in his labors.

It was about this period that subjects were first painted upon pottery. The outlines of the figures were traced in blue or black; the flesh, rendered by the ground, remained white, and the draperies were colored. The drawing is hard and dry; there are no shades or half-tints in the painting, and these early majolica are very curious, in that they have a metallic, iridescent lustre.

The manufacturers of Florence and Faenza were the first to cover their pottery with a white enamel glaze. It is doubtless from this circumstance that the name of fayence, from Faenza, is now improperly given to all the enamelled earthenware of Italian manufacture.

The beauty of this newly-adopted white enamel induced the manufacturers of Florence and Faenza to produce an entirely white earthenware, and when, later, they followed the example of the potters of the Duchy of Urbino, and enriched their fayence with colored designs and arabesques, they often preserved the white enamel ground without covering it with color.

In the manufacture of fine majolica,* after lightly baking the pieces, they were plunged into a liquid preparation composed of oxide of tin, sand and potash, finely ground and mixed with water. The oxide of tin was introduced in larger proportions when a thicker and harder enamel was to be produced. By this simple and rapid process the pieces thus prepared were covered on both sides with a vitrescent coating, which, by its opacity, entirely concealed the dirty color of the paste. Paintings in vitrified colors were then executed upon this coating, and the pieces afterwards taken back to the furnace to receive their complete firing.

The success was apparent, and skilful artists began to devote themselves to painting upon earthenware; they were not satisfied with decorations consisting merely of arms, foliage, ornaments, or single figures; they arrived at the representation of historical subjects, and copied the cartoons furnished for them by painters of reputation. Many sketches for this purpose were made by

* This name is derived from the island of Majorca, where the ware was first manufactured.

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Raphael, and this has given rise to the belief that this great master painted in enamel upon majolica.

After 1560 the cartoons were no longer the sole models of the ceramic painters, who, from this period, began to work from the Flemish engravings. Landscapes, as well as arabesques, became much in fashion, and shortly afterwards the artists almost wholly discontinued compositions of a more elevated style.

The French pottery of the seventeenth century is unique of its kind. Its manufacture was not of gradual growth, but rose at once to a high degree of perfection, and was discontinued, at the end of a few years, without its being known at the present day, by whom or where it was carried on. The paste used for modelling this fayence is a true pipe clay, fine and very white, so that it did not require, like the Italian fayence, to be concealed by a coating or opaque enamel; the decorations are merely glazed with a thin varnish, yellowish, but transparent.

The decorations usually consist of interlaced ornaments tastefully arranged in a style resembling, to a certain degree, the Arabian. These consist of small bands of yellow ochre, with borders of light brown, or designs of a carnation red, formed in the ground itself of the paste—resembling the niello work of Cellini in its finish. These patterns are sometimes disposed in zones of yellow ochre, with borders of dark brown. Other colors are occasionally introduced, but the dark yellow ochre is the predominant one. And in addition to these elegant decorations, this beautiful fayence is enriched with raised ornaments in bold relief, consisting of masks, escutcheons, lizards, frogs, &c. In all of these a pink color predominates. The form of the pieces is always in the purest style of the Renaissance, so finely modelled and so exquisite in execution as to be compared with the chiselled and damascene work of the goldsmiths of the sixteenth century.

There are but thirty-seven pieces of this ware extant, and when these have changed hands, the most extravagant prices have been paid for them.

With the history of pottery in France, the name of Bernard Palissy is intimately connected. He was born in the diocese of Agen, about 1510, and in early life he learned the art of glass

painting. In this capacity he was called upon to ornament with his pencil some of the majolica ware of Italy, and while thus employed he conceived the idea of imitating its enamel, for the purpose of producing a similar ware, moulded after his own designs.

It was a great step to leave an employment that supplied all his wants, to undertake that which offered no certain reward, and promised trials and disappointments without number. He had not the slightest knowledge of pottery, nor could he mould and bake the most ordinary utensil of earthenware. But he had set his heart on the discovery of the glaze that had so charmed him, and for this purpose he constructed a simple furnace, purchased a few earthen pots, which he broke into pieces, and on these placed the different compositions he fancied might possibly produce the desired effect. He had some knowledge of metallic colors, derived from his calling as glass painter, and he was prepared to make other experiments if the first did not succeed. He failed, of course, and new compositions were tried, but with no better results. His ovens or furnaces he repeatedly changed, for he knew nothing of baking clay, and during all this time he was expending his means in a fruitless search, without being one whit the wiser than at the start. Years passed on—years of incessant application to the one study, and years of domestic troubles that would have driven many a one from his home. At his old trade he worked occasionally, to procure means for the support of his family, and buy materials for fresh experiments.

At last Palissy received a government order to survey and map a region of salt marshes—for he was a surveyor as well as a painter on glass—which work occupied him nearly a year, and when he had completed his task he had a larger sum at his command than he had ever known before. Thus fortified, he renewed his experiments, and this time he tried the furnace of a glass-house, where he was surer of a greater amount of heat. Nearly a hundred different compounds were submitted to the action of the fire, in as many little bits of earthen pots, and, to his great delight, some of the compounds melted. This was a great point, and he lost no time in perfecting his experiments.

His trade was now wholly neglected, and his family had but a sorry time of it. His wife had tormented him nearly to death; some of his children had died, and the remaining number were reduced to misery, and he was about to give up in despair. But he resolved on one more trial, which was to be extended to three hundred compounds, fired in the glass-house. One of these completely melted and formed an enamel singularly beautiful.

But now that Palissy had realized his expectations, the next thing was to apply the secret in such a way that, by making its value known, he might realize enough to relieve all his wants. With his own hands he moulded vessels suitable to receive the enamel he had discovered. Then he built a furnace, on which he worked day and night, for he had no means to employ assistance. And when all things were ready he put into the furnace his whole remaining stock of wood, but the enamel showed no signs of melting, and all seemed lost. It was a time for action; more fuel could not be obtained without money, and money he had none, so he tore up the palings of his garden and thrust them into the flames; and when the fiery furnace demanded yet more, the floor of his dwelling was hurriedly torn up and consigned to the devouring element—happily with success, for the enamel melted and the experiment was complete.

But how was the poor man met when he entered his dismantled house? Not with words of congratulation, we may be assured, but with looks that plainly showed his friends thought him insane. It was true he had made the discovery, after years of ceaseless toil and under the most trying circumstances; but now that he was in the possession of the secret that had cost him so much, he could do nothing with it, for want of means. He was not a man to be disheartened, and he at once commenced modelling cups and vases, which he adorned with the most beautiful representations of animals, reptiles, and plants, and when these fell into the hands of the wealthy, he no longer lacked employment or means.

Palissy was a great naturalist, and his vases bear evidence of his love of nature. To the field he constantly resorted when designing, and he modelled always with the utmost accuracy. To

Paris he moved, and there he was constantly employed by the king and his nobles. But he carried with him, besides his art, the principles of the Reformation, which he adhered to firmly. And when the royal edict made death the penalty for exercising the Reformed faith, Palissy, then seventy-six years of age, was thrown into prison, there to await the time when he should be carried to the stake. Efforts were made to save him, but he would not abjure his faith, and he was equally firm when the king in person went to him, declaring that if he could not live to enjoy the religion of his choice, he would die in its defence. Through the remainder of his days he was confined in prison, and died in 1589.

The fayence of Palissy is characterized by a peculiar style, and by several qualities peculiar to itself. There is no flat painting in it, with shaded colors; its decorations consist always of reliefs colored. The enamel is hard and very brilliant, but little cracks may often be observed upon its surface. The colors employed are pure yellow, yellow ochre, a fine indigo blue, a grayish blue, brown, violet, and yellowish white; for Palissy never succeeded in discovering the first object of his researches, the pure white of the Italian majolica; or, at least, he never was able to employ it in his work. The shells with which he ornamented his rustic pieces, are the fossil shells of the Paris basin; the fish are those of the Seine, the reptiles and plants of the environs of Paris; nor is there any foreign production to be met among them.

An enamelled fayence in relief, manufactured at Nuremberg, bears a great resemblance to the works of Palissy, but is inferior both in style and material.

The Portuguese are generally allowed to have been the first to introduce Porcelain into Europe in 1503, but a long time elapsed before any attempt was made to imitate it. Germany has the credit of successfully establishing a manufactory of this kind, and Böttcher, who discovered the art of making hard china in 1708, was the founder of that of Meissen.

Böttcher was born on the 4th of February, 1682, at Schlaiz, in Voigtland, and was placed at an early age with Zorn, an apoth-

ecary at Berlin. Already initiated by his father into the occult sciences, he occupied himself in his master's laboratory not so much with pharmacy as with works of alchemy. A rumor of this spread through Berlin, and fame, never slow to exaggerate either good or bad reputations, already bestowed upon him the title of a maker of gold. His experiments in the transmutation of metals had given him, notwithstanding his youth, an importance in the eyes of Frederick William I. Perceiving that the interest shown by the king would degenerate into persecution, Böttcher secretly quitted Berlin and travelled for three years in Saxony. He did not yet, however, consider himself safe, and, in order to evade the pursuit of the King of Prussia, who wished to seize him to force from him his secret, he placed himself, in 1701, under the protection of Frederick Augustus I., Elector of Saxony, King of Poland, who allowed him to settle in Dresden.

The Elector of Saxony, in granting his protection to Böttcher, no doubt reckoned upon profiting on his own account by the talents of the maker of gold; he ordered Tschirnhaus to receive him into his laboratory and attentively to overlook his work.

Tschirnhaus was a very distinguished scholar. After having travelled almost all over Europe, he went to Paris in 1682, and the Academy of Sciences, to whom he submitted several of his scientific works, admitted him as one of their members. On his return to Germany he applied himself to improvements in optics, and established three glass furnaces, from which were produced wonderful novelties in dioptrics and physics, and particularly a burning mirror, which gained him a great reputation. He was also a very good chemist, and had tried also to make porcelain; but supposing it was only a vitrification, his operations were so conducted as to produce no other result than a milky glass, which had none of the qualities of pure glass.

From the moment that Böttcher was, by order of Frederick Augustus, associated with this learned man, he became very uneasy at his position, beginning already to discover the futility of his researches, although entered upon in all sincerity. But under so distinguished a person as Tschirnhaus, the labors of Böttcher were to take a more useful direction, and his knowledge of chem-

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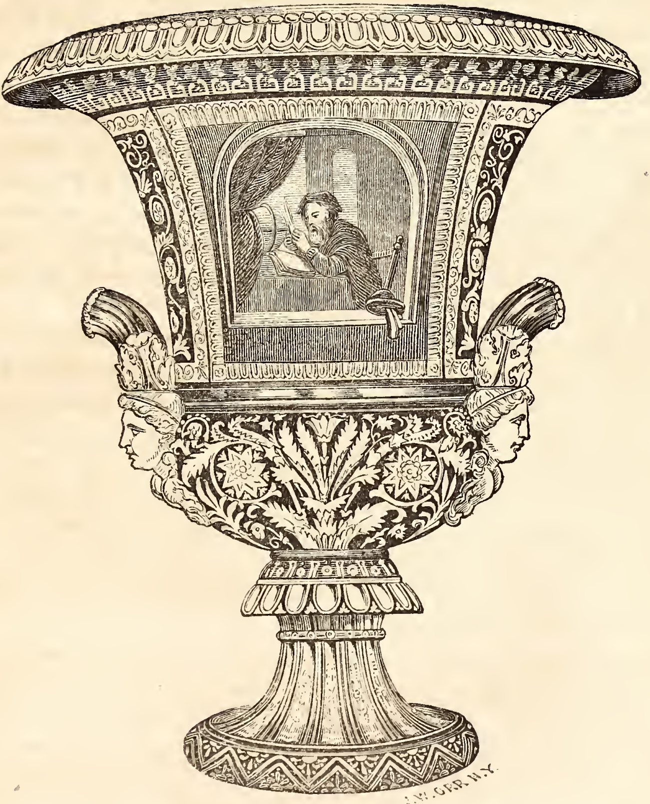
istry could not fail to conduct him to more real and tangible results. The earlier labors of Tschirnhaus led Böttcher to occupy himself with experiments for the discovery of porcelain; but, instead of seeking it, like his inspector, through the process of vitrification, he had recourse to those of ceramics, and thus secured his success. Tschirnhaus, who was extensively acquainted with mineralogy, and who had well studied the clays of Saxony, had furnished Böttcher with a red clay, from the neighborhood of Meissen, to make his crucibles. Böttcher recognized peculiar properties in this earth, and, after various attempts, he obtained, in 1704, a red pottery, dense, solid, very hard, and possessing, therefore, some of the qualities of porcelain, but wanting its translucidity, the most essential of all. This pottery was nothing more than a kind of stoneware; it received, however, the name of red porcelain.

The Elector, under the pretext of withdrawing him from the curiosity of the public, and securing him the quiet needful for his work, had a laboratory erected for him, with a large number of furnaces, in the Château of Meissen. Every thing was given him that he could wish for—a well furnished table, horses and carriages—but he never was trusted out of sight, or permitted to leave the château, without being accompanied by an officer of the Elector, who sat beside him in the carriage whenever he went to Dresden, so fearful were they of his making his escape, and carrying off with him his precious secrets.

While thus restrained, he still continued his experiments, and the seclusion he had to submit to never seemed to affect his spirits. Tschirnhaus died—the workmen could ill endure the confinement—but Böttcher continued his pursuit, and at last he produced a piece of pottery able to resist a high temperature, but the real porcelain he had not yet succeeded in making. The principal material for this was wanting, and chance brought to light that which science had failed to discover. An iron merchant, passing over the territory of Aue, near Schneeberg, remarked that the feet of his horse sank into a white, soft earth. The idea suggested itself to him, of reducing this earth to an impalpable powder, and selling it at Dresden, as a substitute for the hair powder, made



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of wheat flour, at that time in general use. Böttcher's valet-de-chambre used it one day for powdering the wig of his master, who, observing its unusual weight, questioned his servant as to where this powder came from. He learned that it was earthy, made trial of it, and recognized in it, to his great joy, the long-sought kaolin, the substance which forms the principal basis of white porcelain.

At length Böttcher succeeded after some toil, in obtaining, in 1709, a white translucid porcelain, having all the characters of the Chinese. The exportation of kaolin was then prohibited, under the severest penalties; and it was taken to the manufactory in sealed casks. The most minute precautions were employed to insure the secret of the manufacture; all those engaged in it were sworn to silence until death, and whoever betrayed the oath was to be immured for life as a state prisoner.

This desire to keep the process of manufacturing, was not confined to the discovery of Böttcher; it was particularly the case with the fine fayence of Henry II., and although it is supposed to have been made at Thouars, in Touraine, the place of its manufacture is now not positively known. It is evident, however, that the period, when the samples preserved to us were made, was about the time of Francis I. and Henry II.

The process of making the hard porcelain of China, having once been introduced at Meissen, the princes and cities of Germany began to vie with each other in establishing manufactories of this much-sought porcelain. Two ways alone could lead to a knowledge of the process; the one long and difficult, that afforded by science and intense labor; the other more easy, but dishonorable, the corruption of the workmen of Meissen. This latter mode, in some instances, was employed in preference. In this way a manufactory was established in Vienna, and several in Germany.

In France, things went on differently. As early as 1695, artificial porcelain, known as soft porcelain, was manufactured. The composition of the paste of this porcelain had required researches and combinations much more intricate than those which had led to the production of hard porcelain, the latter being obtained by

the mixture of two substances, readily furnished by nature. Kaolin and felspar were of little importance in the composition of soft porcelain; its transparency was given by salts, its plasticity by soap; its glaze was a crystal glass, composed of silex, alkali and lead.

While, during sixty years, hard porcelain had been made in Saxony, France had only been able to produce this artificial porcelain, which could never be considered the same as that of China, the process for the fabrication of which, although constantly an object of pursuit, remained as yet undiscovered. The government, desirous to relieve the country from the large importations of German porcelain, had made an arrangement with the director of the porcelain manufactory of Strasburg for the acquisition of his processes; but these it was found impossible to employ, from the want of the principal materials, kaolin and felspar, which had not been discovered in France.

A bed of kaolin and felspar was found in 1765, in Alençon, but the porcelain made with these materials had a gray tinge, and could not compare with that of the Chinese. Chance soon afterwards led to the discovery of a bed of kaolin, much finer and more abundant, and by which France was at length supplied with a very fine, hard porcelain. The discovery was made by the wife of a surgeon, at Saint Yrieix, who, having noticed a white earth in a ravine near the town, imagined it might be used in washing, for soap. Her husband, who had probably heard of the researches making in quest of porcelain earth, took this with him to Bordeaux, and showed it to an apothecary of that city. The latter sent specimens of it to the chemist, Macquer, who immediately recognized it as kaolin, and after some preliminary experiments it was introduced at Sèvres, for the manufacture of hard porcelain.

The discovery of kaolin, or China stone, in Cornwall, in 1755, led to the manufacture of porcelain in England. Fine ware was made in different localities in 1758 and 1760, and in 1762 Wedgwood very much improved the British manufactures in Staffordshire. But of these we shall have occasion to speak in their order.

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CHAPTER XII.

PORCELAIN.

POTTERY and porcelain are each divided into hard and soft, the term having reference both to the composition and the degree of heat to which it has been exposed in the furnace. Common brick is soft, and fire brick is hard: this will illustrate the difference, and the same characteristics may be applied to all varieties of pottery—the soft yielding readily to the scratch of a knife, the hard resisting it; soft pottery consists of unglazed, lustrous, glazed, and enamelled; hard, of fine earthenware and stoneware. The separating line between pottery and porcelain is the opacity of the pottery. Porcelain altogether depends upon the quality of the materials. The chief ingredients in the composition of all kinds of pottery are clay and flint; these are both classed by the chemists among the primitive earths. The first of them, in its state of purity, is denominated *alumina*, or oxide of aluminum, and the latter is called *silica*, or oxide of silicum.

Clay is an opaque and non-crystallized body, of dull fracture, soft enough in all states to take a mark from iron; when breathed on, it exhales an odor which, from its peculiarities, takes its name from the material and is termed argillaceous. This is owing to the oxide of iron, which is mixed with it, as clay, when absolutely pure, does not emit any odor. Clay forms with water a plastic paste, having considerable tenacity, and which, by the action of heat, is brought to a very great degree of hardness. It is compact, smooth, and almost unctuous to the touch, and when dry

may be easily polished with the hand. It is not soluble in water, but mixes readily with it in all proportions. The description of clay employed by potters is infusible in the heat of a porcelain furnace, where some kinds, owing to their being combined with oxide of iron, assume a red color, while others become of a pure white. The highest temperature to which clay can be exposed increases its density, hardening its substance and diminishing its volume by vaporizing the liquid combined with it.

Silica, or pure flint, which forms the second material of the composition of pottery, is of common occurrence in most parts of the world. Flint is silica in a state nearly approaching to purity. It is usually gray, with occasional striped delineations occurring in the substance. It is obtained generally in rolled pieces, but oftener occurs in irregular shapes. It has internally a glimmering lustre; its fracture is conchoidal, and its fragments are sharp-edged. It is translucent, and when two pieces are rubbed together in the dark, they emit phosphorescent light, and give off a peculiar smell. We are unable to dissolve silex in water, a process that is constantly going on by natural laws. The best flints are of a dark gray color, approaching to black, and having a considerable degree of transparency. The larger masses, dark and clear within and covered with a white crust, are preferred by the potter. The rolled pieces taken from chalk cliffs are of this description.

The clay prized by manufacturers for the finer kinds of earthenware and porcelain, was discovered in Cornwall in 1755, and in every respect resembles the kaolin of the Chinese. It is formed by the decomposition of felspathic portions of granite rocks. It may be considered an artificial production, and the method of preparing it is as follows:

The places are selected where water can be readily procured, and where the rock is in a very friable state, from the decomposition of the felspar. The less of other minerals the rock may contain, and the harder, the heavier, and less decomposed these may be, the better. The decomposed rock, usually containing much quartz, is commonly exposed on an inclined plane to a fall of a few feet of water, which washes it down to a trench, whence

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it is conducted to catch-pits. The quartz, and the schorl, mica, or other materials which may be present, are in a great measure retained in the first catch-pit; but there is a second or even a third pit in which the grosser portions are collected, before the water charged with the finer particles of the decomposed felspar in mechanical suspension is allowed to come to rest in tanks or ponds prepared for that purpose. In these the matter of the kaolin is permitted to settle, the water being withdrawn by means of holes in the sides of the tanks, from which plugs are removed as it gradually parts with the matter in mechanical suspension. By repeating this process the tanks become nearly full of kaolin in a state of soft clay. This by exposure to the air is allowed to dry sufficiently to be cut into cubical pieces of about nine or twelve inches in the sides, which are then carried to a roofed building, through which the air can freely pass, and are so arranged that they become properly dried for sale. When considered sufficiently dry, the outsides of the lumps are carefully scraped, and the pieces of kaolin are sent to the potteries in bulk, or packed in casks, as may be thought desirable.

In preparing the clay, the first operation is that of mixing it with water to the consistency of cream. For this purpose the water must be pure, and the French are in the habit of using only rain-water. To mix the clay it is thrown into a cast-iron cylinder, four feet deep and twenty inches in diameter. Through the centre of this cylinder runs an upright shaft, furnished with knives placed as radii at right angles to the shaft, but so arranged upon it that their flat sides are in the plane of a spiral thread, so that, by the revolution of the shaft, the knives perform the double office of cutting whatever stands in their way, and of forcing downward the contents of the cylinder in the manner of a screw. Another set of knives is inserted in the interior surface of the cylinder, and these extend to the shaft in the centre, parallel to, and corresponding with, the revolving knives; thus the two sets, the one active and the other passive, have the effect of shears in cutting the clay into small pieces; while this, in its reduced state, is at the same time forced through an aperture at the bottom of the cylinder, and transferred to a vat for the purpose of being

mixed with water, a process which this previous division of the clay is found materially to facilitate. In the vat the pulp is mixed to the consistency of cream, and is passed off through a series of sieves of increasing degrees of fineness, washed to and fro by machinery, effecting a separation between the grosser parts of that portion which is fitted to enter into composition of the ware.

The flints are burned in a kiln constructed for the purpose, and not unlike a lime-kiln. While red-hot they are removed from the kiln and thrown into cold water, by means of which their attraction of aggregation is lessened, so as to facilitate greatly the subsequent operation of grinding. Then they are broken and carried to the mill, where they are ground by machinery. To expedite the process, and at the same time to grind the flints finer, a quantity of water is thrown with them into the mill. This is performed in a large circular vat, and when the flints are thus sufficiently ground the semi-fluid is transferred to another vat, also constructed with an upright shaft, furnished with arms or vanes for the purpose of agitation, and a considerable quantity of water being added, the moving power is applied, and the whole set in violent motion. The grosser parts take their place at the bottom, and the finer portion, remaining in suspension, is drawn off and placed in a reservoir for subsidence.

The dilution of clay is held to be of the proper consistency for mixing, when a quantity that will fill a pint measure weighs twenty-four ounces, and that of flint is equally considered suitable for use, when the same bulk is brought to weigh thirty-two ounces.

The clay forms five parts in six of the whole mass; to this are added in certain proportions the flint, already described, gypsum (plaster-of Paris) calcined and ground, and fragments of broken porcelain, which must be white, and ground to a fine powder. The proportions of each vary with different manufacturers. The powder of calcined bones is sometimes introduced in England, together with a small quantity of gypsum, in combination with China clay, flint, Cornish stone, and enamel. A very beautiful and transparent white is thus produced, which, however, is defi-

cient in density, and is very liable to crack on the application of hot liquids.

Prior to the discovery of Böttcher, the porcelain made at Sèvres was composed of saltpetre, sea-salt, alum, Alicante soda, gypsum, and sand. This made the opaque substance known as soft porcelain. It is very like glass in its nature, but will support without softening a greater degree of heat than suffices to melt glass. Arsenic also enters in small quantities into this description of porcelain, and few moulders, after following this employment for some years, escaped severe pulmonary complaints. The manufacture was discontinued in 1804. The porcelain earth used in Berlin is compounded with silicious sand, and sulphate of lime, in crystals. In the greater part of the German manufactories felspar is used, and some employ a calcareous sand.

When the dilutions of clay and flint are brought together, they are intimately united by agitation, and the mixture, while in a state of semi-fluidity, is passed through different sieves, in order to separate any remaining impurities, together with such portions as have not been sufficiently ground. By these means the mass presents the utmost uniformity and smoothness throughout. The affinity which alumina has for silica, under all circumstances, is so great, that they will unite even in the humid way, forming a kind of mortar; and when this becomes hardened by time, it is thereafter incapable of decomposition by the action of the atmosphere.

The fluid mixture of clay and flint is called "slip," and after passing through the sieve, is pumped to the slip-kiln. This is a kind of trough, formed of fire bricks, from forty to sixty feet in length, and from twelve to eighteen inches in depth. Flues from fireplaces pass under the whole extent of the trough, in which the fluid is made to boil, and the process of evaporation is slowly conducted, so as to produce a uniform consistency throughout the mass. This evaporation requires careful attention, and the mass must be frequently stirred and turned over; otherwise, from the imperfect manner in which it conducts heat, the portions in contact with the bricks would become improperly hardened, while the remainder continued fluid· in addition to which, flint

being specifically heavier than clay, would have a tendency to subside to the bottom, and thus render the composition unequal. The evaporation is never carried beyond a certain point, for should the mass become too dry it would be impossible to knead it properly, or to mould it on the wheel into the desired forms.

To remove the air-bubbles when the paste comes from the kiln, it is tempered by working or beating it with wooden mallets; then it is cut into small pieces, which are thrown upon the mass with all the strength of the workman, and these operations are persisted in till the whole is brought to a proper state, when it is allowed to remain undisturbed for a considerable length of time before it is used.

When the paste is to be worked into form, it first undergoes what is called the *slapping* process, which is assigned to a man of considerable strength, who cuts out a piece of about fifty or sixty pounds, and hurls it with all his strength upon the mass, repeating the operation until the whole lump exhibits a perfectly smooth and close appearance wherever it is cut. So complete is the incorporation of the whole mass by this means, that if, at the commencement of the process, two pieces of clay of different colors are taken, the lump will be of one uniform hue, intermediate to the two original colors, when completed. The object had in view in this operation is the removal of all air bubbles, the effect of which will be described before leaving the subject. The process is now effected in some manufactories by steam, pressure being employed instead of slapping.

The operation of *throwing* consists in shaping such vessels as have a circular form. This is performed upon a machine called a potter's lathe, consisting of an upright shaft, about the height of a common table, on the top of which is fixed a circular piece of wood, with a breadth sufficient to support the widest vessel required to be made. The lathe is set in motion by means of an endless band connecting the shaft that supports the circular board on which the clay is shaped, with a large wheel turned by a boy.

The clay to be thrown is first cut, weighed, and formed into a ball. Then it is placed on the face of the circular board, which

is put in motion, and the *thrower*, dipping his hands into water or slip from time to time, fashions the clay into a long thin column, which he forces down into a lump again, and this operation is continued till he is sure no air bubbles remain in the body of the clay. Then he directs that the speed of the wheel shall be moderate, and proceeds to give the first form to the vessel. This is done by the fingers alone, or with the aid of an instrument shaped according to the desired form.

When vessels exactly similar to each other in shape and dimensions are to be made, certain pegs are fixed in a gauge without the circumference of the revolving board, and placed in such a manner that, when the clay is brought to the line thus formed, the thrower knows that the article has attained the proper dimensions. When finished to the workman's satisfaction, it is removed from the lathe by passing a thin brass wire through the lowest part of the cup. It is then lifted off and placed on a board or shelf, to dry partially before it is smoothed and shaped in the turning lathe. This takes place in what is termed the green state, and the proper degree of hardness for it is well known to the workman.

Circular dishes, plates, saucers, and other vessels of that class, are formed in moulds made of plaster. To effect this, the mould is slightly sprinkled with powdered porcelain, sifted through a fine cloth, and is then placed on the block which surmounts the upright spindle of the lathe. The block is then set in motion, and the clay is fashioned in the first place by the hand of the workman, which presses it against the mould, and afterwards with a profile, to give the requisite internal form. If any ledge or foot is required, it is affixed afterwards with slip. All superfluous parts are cut away, and the whole is finished with proper tools and a damp sponge. When sufficiently dry to be taken from the moulds, the edges are pared with a sharp knife, and the pieces are slightly polished by the hand. Then they are placed in piles of from six to ten or more, according to their weight and solidity, and are left to harden, preparatory to their being put into the oven.

The turning lathe of the potter is similar to that used by the

turner in wood. The end of the spindle has a screw thread, upon which are screwed chucks of wood, tapering in their form, and differing in their diameter according to the size of the article to be turned. The tools employed are also of different sizes, from a quarter of an inch to two inches broad, and six inches long, made of iron; the cutting edge being turned up about one-quarter of an inch, and ground to a good edge. The vessel, properly fitted to the lathe, is set in motion; the turner reduces the substance of the clay in such parts as require it, to form rings and rims, and to attend to those little niceties of shape which are not easily obtainable in the throwing lathe, while, by reversing the motion, and applying the flat part of the tool to the vessel with a gentle pressure, the requisite smoothness of surface and solidity of texture is produced. And when a milled edge is desired, it is given in an engine lathe, where, in addition to the rotary motion communicated to the article, it has likewise a horizontal movement to and fro, enabling the workman to make the incisions at proper and definite intervals.

After the vessels are turned, the handles and spouts are affixed by means of slip, with which the parts brought into contact are moistened. In a short time the juncture is found to be perfect, and with a knife the superfluous clay is removed. The whole vessel is then cleaned with a damp sponge, which moistens the whole equally, and gives uniformity to its appearance.

Handles, spouts, and objects of that nature, are made with the aid of a press, consisting of a small metallic cylinder, which has an aperture in the centre of its bottom, to which plugs with different-shaped orifices are fitted. It has also a piston, moved by a screw, which works through an iron bow, attached to opposite sides of the cylinder. The aperture at the bottom is fitted with a plug of the desired form, the cylinder is charged with clay and the piston inserted; by turning the screw the piston is forced down upon the clay, which is forced through the opening in the proper shape. This is cut into length, bent into the required form, and attached to the vessel when sufficiently dry. If the clay is required to take a hollow, cylindrical form, for spouts, a pin of the same diameter of the tube desired is fixed above the

centre of the tube, and the clay is forced over and around it in its passage out. But if ornamental spouts are wanted, they can only be made in moulds of plaster. The moulds are in two parts, and when they are brought together the clay is forced into the space between them; the mould is then divided, the clay is removed and finished by the workmen with suitable tools. This is the operation known as pressing. The moulds are made of plaster-of-Paris, the peculiar fitness of which material for the purpose arises from its property of absorbing water with great rapidity, so that the paste enclosed in it speedily dries in a sufficient degree to deliver itself (according to the workmen's phrase) easily from the mould.

Small ornaments, such as figures, animals, foliage, and the like, are made by pressing the clay into plaster moulds, previously oiled slightly, to insure the easy delivery of the ornaments. These are then affixed to the vessel by means of slip, and it is in this way that drinking-jugs are commonly ornamented with figures.

In order to prepare the plaster for making moulds, it is first ground between a pair of stones, in a mill exactly similar to that employed in grinding wheat. It is next boiled, in order to drive off the water, which forms a considerable constituent part of its natural substance. There is something seemingly absurd in thus speaking of boiling a dry earthy substance, but the workmen who use the term are not very far wrong in their expression. To all appearances ebullition goes on rapidly in the operation, and steam is disengaged as in the boiling of watery fluids. When the process is completed the substance is called boiled plaster. The evaporation is continued in long brick troughs, such as have already been described, and the man who superintends the process is obliged to wear a handkerchief over his mouth and nostrils, to prevent the passage of any particles of the gypsum to his lungs or stomach.

Thus deprived of its water, the plaster becomes an impalpable powder, but when its natural proportion of water is again added, so strong is its affinity for that liquid, and such is its capacity for again combining with itself that which it has been deprived of,

that it attracts and condenses the whole, and will immediately set into a hard and very compact mass, peculiarly suitable for the purpose here required.

The consumption of plaster-of-Paris in making moulds for plates and dishes is so considerable, that in the district comprehending the potteries in Staffordshire, many tons are annually worn out and thrown away as useless.

Articles placed in these moulds part with their moisture so rapidly that, when put in a very temperate stove, they will become dry enough for removal in two hours, and each individual mould is capable of being used for forming four or five different articles in the course of a working day of twelve hours.

Moulds for producing simple wares, such as plates and dishes, and generally for such articles as are formed by pressure, are simple in their construction; but others, which are used for the third department, that of casting, call for much more art and skill for their invention and execution. For these the taste of the modeller is put into requisition, calling for the exertion on his part of a high degree of skill and ingenuity in forming patterns, and adapting to them appropriate ornaments. To complete the model it must be trimmed, carved, touched and retouched with suitable tools, constructed of metal or wood, and sometimes even of ivory, for the more perfect finish of the whole composition. Then it passes into the hands of the mould-maker, whose operations are quite mechanical and distinct from that of the modeller.

A strong case of clay is first formed and securely fixed round the model, leaving sufficient space between for the substance of the mould. Proper proportions of plaster-of-Paris and water are then placed in a jug, and the mixture is briskly stirred, so that the water very thoroughly pervades the whole, which is then poured gently upon and around the model, covering it in every part to the requisite degree of thickness. The drying follows, and in a very short time the mass may easily be separated from the model, when it will be found to exhibit a perfect impression of its form.

Many articles were formerly made by casting, which are now

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produced by the operation of pressing last described. Casting is now employed only for the formation of irregular-shaped vessels, when much nicety is required, and which need not have much strength. The casting operation is performed by intimately mixing the united clay and flint with very pure water, to the consistency of cream. On pouring this dilution into the mould, the plaster quickly absorbs water from that portion which lies in contact with its surface, when the central portion, still in a fluid state, is poured off, and a coating of clay will remain attached to the mould. The coating is allowed to dry in part, and then a second charge, heavier than the first, is poured in and added to the substance of the first deposit. When it has remained there sufficiently long for a portion of it to dry, the surplus is poured off, and so soon as the contents of the mould are sufficiently dry to allow of a separation, the article is taken out and left until it is brought to the green state, when all imperfections are rectified by the workman, whose skill is exerted to render the vessel as smooth and perfect as possible.

When the vessels that have been moulded are in a fit state to undergo the first application of fire, they are placed in deep boxes, called seggars, made of a mixture of fine clay and old ground seggars, which should be well baked and capable of resisting the most intense heat without being fused.

The object of the seggar is to protect the ware, while baking, from the direct application of flame and smoke; and the heat, which is somewhat modified in its transmission through them, applies itself uniformly to each part of the vessel. The cases are made of various sizes and depths, to suit the different pieces they are to contain, and some judgment is required in their composition, to fit them for the several kinds of pottery. Again, skill is required so to dispose the cases within the oven, with reference to their shape, size, and the objects they contain, that the heat may be distributed as faithfully as possible, and that all the different-sized vessels may be sufficiently baked at the same time. The larger and coarser pieces are usually placed on the floor of the oven, which must be previously covered with a layer of sand. If the heat be not faithfully distributed through the whole area,

some pieces must be injured by excessive firing, while others would be inadequately baked. The bottom of seggars being flat, each, as it is placed upon another, forms a cover to the one below, and the entrance of the smoke is further prevented by placing a ring of soft clay on the upper rim of each case. In this manner the seggars are built one upon another, until they reach nearly to the top of the oven. The upper seggar in each pile is always empty, and, in building them up, intermediate spaces of about three inches must be left for the circulation of heated air throughout.

To prevent any adhesion of the pieces to the seggars, the flat bottom of each is covered with a thin layer of white sand, and the Chinese strew over the sand some dry kaolin. Pieces of any considerable size must each be enclosed in a separate case; but smaller objects, such as cups or saucers, may be placed together to the number of six or twelve, but in no case must one piece be placed in or on another in the seggar, and all must be so arranged that the heat will be equally applied to every part of each.

The potter's oven is now always made of a cylindrical form, and very similar to the common kilns used for burning tiles. The furnace mouths of the oven are placed at certain intervals around it; from these the fire and heated air pass into horizontal flues in the floor, and then ascend through all the interstitial spaces between the seggars, until the surplus heat escapes through an aperture in the roof.

The Chinese subject the greater part of their porcelain to only one firing, first drying the pieces sufficiently in the air to prepare them for glazing. This plan they are able to pursue, because the nature of their material is such that it resists the entrance of water. Their glaze is much superior to any in use in European potteries; but it requires the most intense degree of heat for its fusion, and considerable art is consequently required for the management of the fire, as well as in the construction of their ovens. These are built in the most substantial manner, so that when the fire is at its greatest height the hand may be applied to the outside without any fear of burning.

Great attention is necessary for properly conducting the operation of baking. The heat must be sufficient to expel all the moisture, and occasion the cohesion of the parts whereof the paste is composed; but if carried too far the texture of the ware becomes too homogeneal, and it is rendered brittle. It requires a degree of heat sufficient to melt silver (1873 Fahrenheit) in order to expel the last portion of water from clay, and when this has been effected, it is found that the weight of alumina is diminished forty-six per cent.

The process of baking usually lasts from forty to fifty hours, during which time the heat is gradually increased, as it would be injurious to apply a very high degree at first. In order to ascertain when the baking has been carried far enough, the *oven-man* places trial pieces in different parts of the oven, but so disposed that they can readily be taken out for examination. These pieces are rings of common Staffordshire fire clay, which has the property of changing its color with each accession of temperature. By comparing these rings, therefore, with pieces of the same clay, which have previously been sufficiently baked, and which serve as a standard, the actual progress of the wares in the oven may at any time be precisely ascertained. When the appearance of these trial pieces is judged satisfactory, the firing is discontinued, furnace and ash pit doors are closed, and the oven, with its contents, left to cool gradually during twenty-four hours. It is not necessary to delay the withdrawing of the pieces from the oven until they become quite cold, but the sudden alteration of the temperature would occasion them to crack, if they were taken out while their heat was greatly above that of the atmosphere.

From the similarity of its appearance to well-baked ship-bread, the ware in this stage is called *biscuit.* Its permeability to water when in this state fits it for being employed in cooling liquids. If previously soaked in water, the gradual evaporation from its surface, by means of the air, causes an absorption of heat from the surrounding atmosphere, which is again supplied by neighboring objects, until an equilibrium of temperature is restored.

If it were attempted to apply the glaze to articles of porcelain and earthenware, without their previous conversion into biscuit, their shape and texture would be injured by the absorption of water from the glaze. Neither would it, for the same reason, be possible to ornament the ware by painting, or to transfer patterns to the surface by printing. There is another reason given for the necessity of this previous baking, in the greater contractibility of the clay than of the glaze, which would crack and peel off if the limit of contraction had not been previously attained. It will be remembered that the shrinking of clay upon the application of heat is permanent, and that no alteration of its bulk will occur, unless it be subjected to a still higher degree of temperature. By limiting, therefore, the heat of the glass oven in which the baking is finished, below that applied to the biscuit, the evil of cracking the glaze, through the contraction of the ware, is avoided.

Glazes for porcelain and the finer kinds of earthenware, are generally made with white lead, ground flints, ground flint glass, and common salt. Sand, combined with soda, as a flux, being frequently added to the ingredients just mentioned. Almost every manufacturer uses a peculiar glaze, which is kept secret by him as much as possible. It is necessary to vary the composition of the glaze in order to suit the different materials that form the body of the ware, since that would be a very fine glaze for one mixture of earth, which would be wholly inappropriate to another, proving deficient in lustre, and liable to crack.

The qualities which it is the object of the manufacturer to give to porcelain of the first description, are, density, whiteness, transparency, and fine texture of the glaze. These properties are esteemed in the order enumerated, compactness of body being the point it is considered most desirable to attain. The glaze, as seen in the finished porcelain, should not put on a lustrous appearance; but, while beautifully smooth to the touch, should present to the eye rather the softness of velvet than the gloss of satin. This peculiar semblance will only be produced with glaze that melts with difficulty, and when the heat has been raised pre-

cisely to, and not beyond, the point that is necessary for its fusion.

Porcelain buttons, sometimes called agate buttons, are readily made, on the principle of forming mosaic tesseræ, by a machine invented for that purpose, and in 1837 the first button was made by it. The buttons are made by what is known as the "dry process," i. e. by a pressure sufficiently great to compress the dry porcelain powder into a hard and enduring shape. They are made by women, who often turn out twenty-five buttons in a minute, but the usual rate is from twelve to eighteen a minute the year round. The price paid is one cent per gross, at which rate one woman earns from three dollars to four and a half dollars per week. Bricks and tiles, tesseræ and joints for fireplaces, keys for pianofortes, and, in short, all kinds of flat articles have been, and still continue to be, made in almost endless quantities in this way, and floors are not unfrequently laid with the same material.

Stoneware is a very perfect kind of pottery, and approaches nearer than any other description to the character of porcelain. Its body is exceedingly dense and compact, so much so, indeed, that although vessels formed of it are usually glazed, this covering is given to them more with a view to improving an attractive appearance than for preserving them from the action of liquids. When properly made and baked, stoneware is sufficiently hard to strike fire from flint, and is as durable as porcelain.

The basis of English stoneware is blue clay, brought from Dorsetshire and Devonshire, where it is found twenty-five or thirty feet below the surface. This clay is very refractory in high heats, a property which, joined to its whiteness when burnt, renders it peculiarly valuable for pottery. It is also the basis of the yellow biscuit ware, called cream color, and in general of what is called the printing body; as also for the semi-vitreous porcelain of Wedgwood's invention, and of the soft porcelain. Porcelain differs from stoneware in having a flux mixed with the clay, so that a semi-vitrifaction results in the process of firing. The Queen's ware and cream-colored bodies of Wedgwood are composed of Cornish China clay, with a large admixture of blue

clay, black clay, brown clay, and calcined flints. In the blue ware, and such as are printed with fancy patterns, there is an addition of a tolerably large quantity of decomposed granite. All the parts are worked together much after the manner already described.

The origin of the improved stoneware is traced to the observations of Ashbury, a potter, who, while travelling to London on horseback, in 1720, had occasion at Dunstable to seek a remedy for a disorder in his horse's eye, when the hostler of the inn burnt a flint, and reduced it to a powder, which he immediately blew into the diseased eye. The potter observed the beautiful white color of the flint when calcined, and resolved to apply it in his art. He preceded Wedgwood.

In every way Wedgwood is regarded by his countrymen as a benefactor; as a manufacturer he improved the articles which he produced, and thus improved the trade of the potter. The terra-cotta which he made to resemble porphyry, granite, and Egyptian pebble, was not only, as a material, superior to any thing previously made in England, but he introduced it to the public in forms of exceeding elegance. His Basaltes, or black stoneware, realized in every sense its name; it will emit sparks when struck with a steel, it is capable of a very high polish, resists the actions of the strongest acids, and is infusible at any ordinary furnace heat. The white porcelain ware was of the same general character as the preceding, differing from it only in its pure white character. The Bamboo and Jasper were essentially stonewares, and from the state of semi-fusion to which they were subjected, they could be made to absorb the same coloring bodies—metallic oxides—as are used to color glass, or in the process of enamelling. The table ware, better known as Queen's ware, already referred to, (so named in compliance with the wishes of the Queen, who admired the production,) was in every respect superior to any thing hitherto manufactured in Europe.

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CHAPTER XIII.

PORCELAIN.

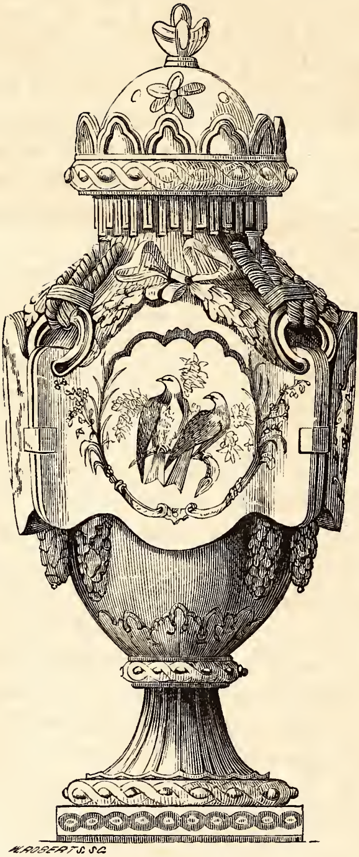
IN painting on porcelain, many points are to be considered, and a proper acquaintance with the colors to be used and the nature of the fluxes, is necessary to successful operations. The fluxes render the composition of the colors fusible, unite them to the wares, and, in many cases, impart brilliancy to their tints. The vehicle employed in laying on the colors must be looked to, and the course to be pursued in fixing them on the porcelain by means of heat, must be understood.

Metallic oxides form the basis of all vitrified colors, but every metallic oxide cannot be employed in decorating porcelain; some are highly volatile, as the oxide of mercury and of arsenic; others part so freely with oxygen they hold in combination, that their color proves uncertain, and varies with every application of heat; such are the peculiarities of the red oxide of lead, and the yellow oxide of gold. Black oxide of iron is not used alone for producing that color in porcelain. It affords a great variety of tints, both in the various combinations of its own oxides and their mixture with those of other metals. Alone it affords a red, a brown, and a violet; and mixed with the oxides of cobalt, or oxides of zinc, it furnishes a black, a gray, sepia and yellow. The colors formed by the oxide of iron will not, however, stand the greatest heat of the furnace; it combines at a very high temperature with the flint of the body, and thus becomes a colorless silicate of iron. But if the quantity of the oxide of iron be increased considerably

above the quantity that will combine with the silica of the felspar, a reddish-brown color is obtained, called technically, *brown-lake.* By careful attention to calcining the sulphate of iron, orange-yellow, then red, carmine, lake, and lastly, violet, can be obtained. The browns, grays, and blacks, for porcelain, are produced with oxide of iron formed by precipitation from some persalt by ammonia, potash or soda. Emerald green is produced by employing a mixture of oxides of copper and iron.

Oxides, unaccompanied with other substances, are not susceptible of fusion; and although they may be attached in their strata to vitrifiable bodies by a very violent heat, yet their colors, with the exception of lead and bismuth, would, in such cases, become dull, and possibly be even destroyed. In order, then, to promote a fusion, a flux is added, the composition of which varies according to the means employed for diluting the colors at the time they are used. Where a volatile oil is chosen for the dilution, a flux composed of glass, nitre and borax, is most proper; but when, as in the Sèvres manufactory, gum-water is substitued, the flux must be varied, because borax cannot be properly diluted in gum-water. Glass, lead and silex is one compound recommended; and glass, calcined, borax and refined nitre is another. It is indispensable not only that the borax and nitre be as pure as they can be rendered, but also that the glass shall not contain the smallest particle of lead in its composition. These ingredients must first be well triturated together in a glass mortar, and then exposed in a crucible to the heat of a charcoal fire, until the swelling, which for a time accompanies the fusion of the mass, has ceased. By means of this flux, the colors are fixed upon the porcelain, and made to assume a resplendent appearance; the metallic oxides are enveloped by the flux, which preserves them from all contact with the air, and their color is rendered permanent, the fusion having been promoted at a temperature too low for their destruction.

Enamel is glass made opaque by the oxide of tin, and rendered fusible by the oxide of lead. All glazes that contain lead participate in the properties of enamel. Raw glazes, used for covering tender porcelain, are of this nature. The colors employed in



PORCELAIN VASE—PAINTED. p. 223.

painting this porcelain are those which serve for painting in enamel. They require less flux than others, because the surface to which they are applied becomes soft enough to be penetrated by them. Hard porcelain, identical with that of China and Saxony, has two kinds of colors applied to it. Those of the first kind, which are used in the representation of different objects, are baked in a heat much below that necessary for baking porcelain; while the other colors, which are few in number, must be exposed to the highest degree required by the porcelain itself. The glaze used for hard porcelain has little or no lead in its composition. The Sèvres manufactory, and some few in England, employ felspar without any mixture of lead, This glaze, when exposed to the heat of the glass oven, dilates, and its pores are opened, without becoming soft, so that the colors are not absorbed by it, and do not undergo those changes which occur when they are applied to soft porcelain, when, by mixing with the body of the enamel, they become faint and indistinct. This effect is much increased, when some particular colors are employed, and especially the reds produced from iron, which are exposed to the destructive action of the lead that is contained in the glaze.

Painting on soft porcelain must, for this reason, be several times retouched with the pencil, in order to give to it the distinctness and brilliancy which follow the use of the same colors on hard porcelain, so that a high degree of ornament is seldom or never given to any but the latter description. In the embellishment of hard porcelain, these retouchings are not required, except for the most elaborate specimens of the art, which can, by such means, however, be produced with the most admirable degree of perfection, so as to render painting on porcelain not distinguishable from the finest productions of the pictorial art, without reference to the body upon which it is performed, or the means used for bringing out the colors. Natural objects, landscapes, portraits, and historical pieces, are represented with all the truth, as well as all the brilliancy of coloring, of similar subjects on canvas.

The service presented by the King of Prussia to the Duke of Wellington, in 1816, is said to be the finest specimen of Dresden

porcelain in England. Each piece is exquisitely painted, and the battles represented, and all the subjects, are different.

One great inconvenience attending the repeated exposure to the heat of the oven of pieces thus retouched is, the colors are liable to peel off unless the greatest care has been used in their application. This defect has been remedied in the Sèvres works, by introducing a calcareous flux into the felspar glaze, which softens it, without at all affecting the body of the ware. Soda and potash are never used as fluxes, as their introduction causes the colors to scale; the reason of this is, they become volatile in a great heat, and abandon the color, which will not adhere to the glaze.

The liquid which serves as a vehicle for laying on the colors, is rubbed with them on a glass palette, till the whole is entirely combined. Great care is used in the choice and management of diluent liquids, which must always be sufficiently volatile to be entirely dissipated in the heat to which the wares are afterwards exposed. In France the preference is given to oil of lavender as a vehicle; and in order to insure the proper degree of fluidity, the oil is divided into two parts, by distillation; that which first comes out being the most volatile, and having the least density, is used for diluting the colors when they become too thick; and, on the other hand, the portion that remains in the retort having the opposite quality, is reserved for thickening them when they run too freely. Oil of turpentine, which has been some time in store, is more generally used in England, and is said to answer the purpose better than any other volatile fluid.

The European porcelain painters are not confined to a limited palette,—scientific investigation having brought to their aid a variety of beautiful colors, which suffice for all the wants of the artist when employed in transferring the most elaborate designs to porcelain. Purple and violet are procured by dissolving gold in aqua regia, and immersing a bar of pure tin in the solution. This is called the purple of Cassius, and a better way of preparing the precipitate is, to dissolve the two metals separately, and then, by bringing the two solutions together in different proportions, various shades of carmine, violet, and purple are obtained. These

three shades cannot bear exposure to the full heat of the furnace. When first applied on the porcelain, the precipitate of gold is of a dirty violet color, but a moderate heat changes it to a beautiful purple.

The red oxide of iron is prepared by the united action of fire and nitric acid. The color is beautiful, but less brilliant than that produced from gold. Shades of red, deepening from rose color, and passing, by the increased action of heat, to brown, are obtained from iron. Various shades of reddish brown are obtained from the admixture of black and red oxides of iron. A very permanent red color is obtained by calcining the oxide of iron with double its own weight of common salt.

Yellow is obtained from the white oxide of antimony, mixed with sand and oxide of lead, the latter substance serving as a flux to the others. Oxide of tin is sometimes added, and when an approach to saffron color is required, red oxide of iron is added. Straw color is obtained by mixing oxide of uranium with oxide of lead, and another yellow color from the chromate of lead. Naples yellow is composed of ceruse oxide of antimony, and sal-ammoniac, calcined together at a moderate heat for three hours. The shade is raised or diminished by the proportion of sal-ammoniac.

Blue is obtained from the pure oxide of cobalt, and oxides of tin and zinc, added in different proportions, giving different shades, from a deep rich color to a light blue. The blue of Sevres owes the superiority of its color to the careful preparation of the cobalt for that purpose, and the dull color which appears upon much of the English porcelain and earthenware, arises entirely from the admixture of the oxide of iron, arsenic, copper and lead with the oxide of cobalt. One twenty-thousandth of a grain of oxide of cobalt will impart a very sensible blue tint. This very important color may be used equally well on ordinary earthenware, baked at a low heat, and on porcelain, which requires an elevated temperature.

Many of the Egyptian pastes of blue and green have been found, upon analysis, to be covered with a color derived from copper, and the same metal was also employed by the Assyrian

potters, to impart a color to their earthenwares. Green is still obtained from the oxide of copper. Various shades of beautiful green may be obtained by mixing, in different proportions, Prussian blue with chromate of lead. A mixture of the oxide of cobalt and nickel will resist a very intense heat, producing an olive color. A beautiful green color, indestructible in the heat of a porcelain furnace, is obtained from the oxide of chromium.

Browns we have already made mention of, under the head of oxides of iron.

Blacks are produced by combination, for there is no metallic oxide which will alone give a good black. The oxide of manganese, brown oxide of copper, and a small proportion of oxide of cobalt will do it; while a gray color is produced by omitting the copper and increasing the quantity of flux. Cobalt, oxide of copper, and umber make a good black, and the same color is obtained from oxides of copper and iron, with smalt.

A brilliant white is obtained from one part of virgin tin, and two parts of common salt. This white may be advantageously employed in painting with oil, as it mixes well with it. When used on porcelain, it must be mixed with three times its weight of flux.

By making different mixtures of the colors here described, every tint that can be desired may be obtained. Great judgment in the selection of materials, care in their preparation, and a knowledge as to the relative proportions wherein they should be brought together, are essential to success, and, as well as an acquaintance with the science of chemistry, are all highly desirable. There are some colors which, if mixed together, would mutually destroy each other, and in the exposure of metallic oxides to heat, changes ensue which result not from the nature and habitudes of the colors themselves, but rather from the influence of the bodies to which they are applied.

The gold used in gilding porcelain is applied in a metallic state. To prepare it for this purpose, it is dissolved in aqua regia; the acid is subsequently dissipated by the application of heat, and the gold remains in a state of powder at the bottom of the vessel. This powder must be mixed with borax and gum

water, as a vehicle for causing it to flow from the pencil and fix upon the ware, and when it is baked the gilding appears void of lustre. It is then burnished with either agate or blood stone. Gilding in the Sèvres porcelain is much less abundant than in the commercial China ware of France, and thus it gains largely in taste. Porcelain, if over-gilt, has a metallic appearance.

Gilding on porcelain, or on glass, is performed either with or without the addition of a fluxing material: the gold being made to adhere to the surface by the incipient fusion of either the glazing or the porcelain, or of the surface of the glass, or of the flux employed.

Gold is used for this purpose sometimes in the form of leaf-gold, and at other times in that of powder. When the first of these two methods is employed, leaf-gold must be ground with honey, or with gum water of an equal consistency; the honey or gum is then washed away, and the gold is kept for use in papers or in shells. The use of these latter recipients has occasioned the powder to be known among artists as shell-gold.

Gold is precipitated from its solution in aqua regia, by adding to it a watery solution of green vitriol, or strips of metallic copper. When the powder thus obtained is to be used, it must be mixed with gum water as a vehicle. When it is intended to apply leaf-gold without any fluxing material to the body of the wares, these should be moistened in the requisite parts with a weak solution of gum water, which must afterwards be allowed to dry. When the gold is applied, the porcelain or glass may be made sufficiently adhesive by breathing on it. Japanese gold size, moistened to the requisite degree with oil of turpentine, is sometimes employed.

The next and last process is the burnishing. This is intrusted to female hands. The implements required for the purpose are, a burnisher of agate or blood stone, some white lead, a piece of sheep-skin, for wiping the ware, and some vinegar. As extreme cleanliness is indispensable, the person engaged in burnishing does not even touch the porcelain or her implements, but interposes between her work and her hands a piece of clean white linen. With her hand thus covered, she applies the agate burnisher

lightly to the gilding, following all the ornaments, and never rubbing in cross directions, lest the gilding should appear scratched. After having rubbed the gilding for some time a little vinegar or white lead is applied, to clean the surface. This is removed with a soft linen rag, the burnishing is recommenced and continued until the gilding throughout assumes a satisfactory appearance.

Gold and silver *lustre-ware* is commonly of an inferior quality. The metallic oxides used for covering these vessels are intimately mixed with some essential oil, and then brushed entirely over the surface. The heat of the enamelling oven, which dissipates the oxygen, restores the oxides to their metallic state, but with diminution of their brilliancy. The oxide of platinum is used for making silver lustre.

Colors, when they are required for use, should be first pounded quickly in a mortar made of either porcelain, agate, or glass, with a pestle of the same, and covered, to prevent the access of dust. They must afterwards be ground on a glass palette, and the artist who decorates porcelain is required to rub his colors with as much nicety as a miniature painter. The requisite proportions of volatile oil and of flux are added and ground with the colors on the palette, the whole having been carefully weighed before their union. They are then applied to the porcelain by means of a sable or camel-hair pencil.

At the Sèvres manufactory, primary studies for the composition, lights and shades, &c., are made; then there is a drawing in tempora for arranging the colors, and subsequently an elaborately finished oil painting of the whole, as it will appear when complete, is produced. In this way great perfection is attained. The designs, many of which we have introduced in these pages, are high in character and broad in treatment, and in the drawing there is a wonderful degree of accuracy. Each theme is studied thoroughly, and executed with a precision and force indicative of a fixed purpose, and a full appreciation of all that is required to be done.

After the pieces have been painted, it is necessary to dry the colors by evaporating the oil used with them as a vehicle. Then they are placed in the enamelling kilns, which are in form like a

chemist's muffle. The articles are piled in the kiln until it is filled, when the mouth is closed and the fire applied. The heat is continued for eight or ten hours, at the expiration of which time the colors are burnt into the glaze.

The style of decoration already described is in a great measure confined to the most costly descriptions of porcelain. Wares lower in price, and which can be brought into more general use, undergo a different kind of embellishment. A great variety of neatly printed patterns are transferred to their surface from impressions previously printed on paper.

The method of transferring printed designs to earthen vessels may be thus described: The landscape or other pattern is engraved upon copper, and the color, which is mixed with boiled linseed oil, is laid on the plate in the same manner that ink is usually applied by copper-plate printers. To increase the fluidity of the oil, the plate is then temporarily placed in a stove. When it is withdrawn a sheet of damp tissue paper is laid on it, and both are passed through the press in the ordinary manner. The paper, wet with the color, is then delivered to a girl, who reduces its size by cutting away the blank portions surrounding the pattern, and passes it to another girl, by whom the impression is applied lightly to the ware when the latter is in the state of biscuit. A third girl is next employed, who, with a piece of woollen cloth, rolled tightly in the form of a cylinder, rubs the paper closely against the piece in order to press the color sufficiently into its substance. The paper, thus rubbed, is left adhering to the article for an hour, when it is placed in a cistern of water, so that the paper may become soft enough to peel off without violence to the impression the biscuit has received from the copper-plate.

When the pieces thus printed have stood a sufficiently long time to become dry, they are placed in an oven, to which a gentle heat is applied, in order, by dissipating the oil, to prepare the way for the glaze. This is, of course, completely transparent, as otherwise the distinctness of the pattern would be impaired. The glaze is vitrified in the glass oven in the manner already described.

The French potters employ a sheet of glue, rendered flexible

and of the consistency of leather, to transfer the design from the copper-plate to the ware. In this way two impressions are given to the ware without a fresh application of the glue to the plate.

Parian statuary biscuit does not differ materially from that employed in the manufacture of porcelain. The chemical elements of the composition are essentially alumina (pure clay), silica (pure flint), and an alkali (potash), which, by the action of the intense heat to which the mass is exposed, actually agglutinates so as to form the beautiful body which the finest figures present, the perfection of which is still more apparent in a fractured portion. Every manufacturer employs different proportions of each substance, and it often occurs that some material peculiar to a certain manufactory marks its character.

The materials are combined and used in a liquid state, technically called "slip," about the consistency of thick cream. It is poured into the moulds forming the figures or groups, which, being made of plaster-of-Paris, rapidly absorb a portion of the moisture, and the coating immediately in contact with the mould, soon becomes of a sufficient thickness for the cast, when the superfluous slip is poured back. The cast remains in the mould for some time, at a high temperature, by which it is (through the evaporation that has taken place), reduced to a state of clay, and sufficiently firm to bear its own weight when relieved from the

moulds, which are then opened, and the different portions of the subject taken out.

Each figure requires many moulds; the head, arms and hands, legs, body, parts of the drapery, when introduced, and the other details of the subject, are generally moulded separately. Often, upwards of forty moulds, and these of several divisions, are used for one group. The parts, when removed from the moulds, have to be repaired, the seams, caused by the junctures of the mould, cleaned off, and the whole put together. This is a process requiring the greatest nicety and judgment, the fragile nature of the material in its present state, needing considerable practical knowledge necessary to form a perfect union of the different members, and they must also be so disposed as to be in strict accordance with the original mould.

Peculiar care is required in putting together nude figures, in which the juncture of the parts generally presents a level circular surface, requiring the decision of an educated eye, to unite them with accuracy. Surfaces that present a marked and broken outline, which will fit together only at one particular point, are exempt from this difficulty. The parts are attached together by a slip, similar to that used in casting. The delicate effect of the light and open drapery sometimes produced, is attained by dipping a piece of net or lace (from which the original matter is burnt in the subsequent firing), in this slip, and applying it in accordance with the original design.

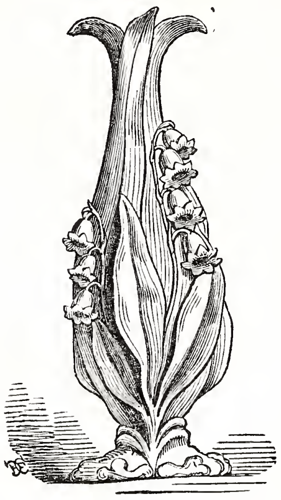
The figures or groups thus put together, remain two or three days, or until they are sufficiently dry. Each figure is then supported by props made of the same materials, placed in such a position as to bear a portion of the weight, and prevent an undue pressure, that might cause the figure to sink or yield in the firing. Each end of the prop is embedded in a coating of ground flint, to prevent adhesion, and is thus easily removed. The figure is now placed in the oven and fired.

The operation of firing occupies from sixty to seventy hours. The fires are then withdrawn, and the oven allowed to cool, and when sufficiently so, the figures are taken out and the seams rubbed down. Then they are embedded in sand, and refired at a

still higher temperature. The bedding of sand is preferred in this part of the process to the props, as it more equally and effectually supports the figure. It could not be used in the first instance, when the figure was in the clay; as, by resisting the contraction, it would cause it to be shattered to pieces. It is even sometimes necessary to fire casts three times, a peculiar degree of heat being required to produce the extreme beauty of surface which the finest specimens present.

The total contraction of figures, from the mould to the finished state, is one-fourth. The contraction of the slip with which the mould is first charged, is one-sixteenth; it contracts another sixteenth in the process of drying for the oven, and one-eighth in the process of vitrification; so that a model two feet high will produce a fired cast of only eighteen inches.

Now let it be considered that this contraction should extend in an equal degree through every portion of the subject, to insure a perfect work, and it will be immediately apparent that there is considerable difficulty to be overcome in its production, particularly to achieve such a result as would satisfy the requirements of



a highly cultivated taste. Still, difficult as it may be, and is, with judgment in the selection of the subjects, and practical knowledge brought to bear in the execution, there is no improbability in the conclusion that a faithful realization of the beauties of the finest work of art may be produced. Already we have given several illustrations of the beautiful works that are readily produced at some of the leading manufactories in England. The beautiful statuette of Psyche, on page 230, is after the design of Carrier. The group opposite represents a young girl listening to Cupid, and is called "The First Whisper of Love." And the same beautiful material is applied to many objects of daily use, which, in the hand of the modeller,

[FIRST WHISPER OF LOVE—PARIAN.

VASES, ETC., IN PARIAN.

p. 233.

have been made to take shapes of beauty that entitle them to our attention. Pitchers, tea-sets, vases—a little one, composed of the leaves and flowers of the lily of the valley, we here introduce. Fruit dishes, centre pieces, many of them of great beauty; brackets, pedestals, and other articles of like description, and which admit of a fine display of taste in their adornment, are made equally attractive.

And before leaving the subject of Parian statuary porcelain, we should here speak of its rival for popular favor, known as Fictile ivory, now so popular, and the discovery of which has enabled the inventor to place within the reach of all, admirable copies of the most beautiful ivory carvings, the originals of which, from their rarity and expensive qualities, are placed beyond the reach of all but the wealthy. This preparation is composed of the finest plaster-of-Paris, which, by nice manipulation, is made to absorb stearine, or some similar agent. When the requisite cast is taken, the imitation of ivory is most perfect.

All the materials for making articles of crockery, China, and glass ware, as good as the finest English wares, are to be had in this country; but the high price of labor prevents the manufacture except to a very limited extent. The pottery of the Earthenware Manufacturing Co., at East Boston, has been in operation four years, and their business the past year amounted to forty thousand dollars. And at Bennington, Vt., the United States Pottery is producing works that reflect the highest credit on the manufacturers. A specimen, in the form of a fruit dish, may be found among our illustrations.

CHAPTER XIV.

CHINESE METHOD OF MANUFACTURING PORCELAIN.

THE Chinese call one of the principal ingredients of their porcelain "kaolin," to which we have frequently alluded in our remarks on the European process of manufacturing; the other ingredient is called by them "pe-tun-tse." The first is the infusible portion, and is found mixed with a shining substance, resembling mica. The second, the fusible, is of a brilliant white, exceedingly fine in the grain, and soft to the touch. The kaolin constitutes the body, or "bone," as it is called, and the pe-tun-tse the transparent glaze, for which the ware is celebrated. They are both found in mines or quarries situated between twenty and thirty leagues from King-te-tching, where, from the earliest ages, the manufacture has been carried on. These earths are supposed to improve by exposure to the air, and for this purpose they are left in heaps, surrounded by ditches to draw the water off from them, and the potter turns to account the materials gathered by his grandfather.

The pe-tun-tse is dug out of the solid rock in the form of squares, and about the size of common bricks. In this state it is taken to the manufactory in small vessels, and there it is ground to a powder by means of hammers. When it is almost impalpable it is thrown into a vessel of water, and stirred briskly about. After the water has rested for a time, a white substance, in the

form of a scum, rises to the surface to the thickness of two or three inches. This is skimmed off and placed in another vessel, and the process continued till nothing remains but the coarser particles, which are put under the hammer for a fresh grinding. When the water in the second vessel becomes quite clear, it is poured off, and the sediment at the bottom, in the form of paste, is taken out, and is ready for combination with the kaolin. This part of the work is performed by those who confine their attention exclusively to it; and the pe-tun-tse, thus prepared, is sold to the porcelain makers, in square and dry blocks, at so much a hundred, who have to test them first, to guard against buying the foreign matter artificially mixed with the paste.

The "bone" of the porcelain is made of kaolin, which is much softer than the pe-tun-tse when dug from the quarry, and is prepared in the same way, but with much less labor. Kaolin is known, from the particles of mica which it contains, to have its origin in felspar, or graphic granite. It is infusible with the heat of a porcelain furnace, even in China, the degree of which must be tremendous, as some of the materials employed in their glazes could not be vitrified at a lower temperature than would suffice to fuse Cornish granite. It is the kaolin that gives strength and body to the porcelain, and, consequently, this, or some substance possessing the same quality, forms an indispensable ingredient in its composition. It is related of some Europeans, that having privately obtained some blocks of pe-tun-tse in China, and conveyed them to their own country, they vainly endeavored to convert them into porcelain, which, becoming known to some of the Chinese, they deridingly remarked, "that certainly the Europeans must be a wonderful people, to go about to make a body whose flesh was to sustain itself without bones."

The two substances described as oil or varnish are procured, one from a combination of pe-tun-tse with another mineral substance, and the other from lime. In the preparation of the first of these, such stones are selected as have the whitest appearance. These undergo the same process of washing and grinding as have already been described, except that the creamy substance, when it has subsided in the second vessel, is not all put into moulds,

but only the upper and finer stratum is gathered for the preparation of this varnish. To each one hundred pounds of the substance thus separated, one pound of a mineral called she-kao, which is a kind of gypsum, is added. This stone, which resembles alum in its appearance, is first raised in a furnace to a red heat, and then reduced, by pounding and rubbing in a mortar, to a very fine powder, in which state its union with the purified pe-tun-tse is effected, the consistency of the compound being perfectly fluid.

The preparation of what is called "oil of lime," the fourth ingredient required, is thus managed: Lumps of quicklime are first sprinkled with water and reduced to a powder; upon this a bed of dried fern is placed; then another layer of lime, covered again with fern; and so on, alternately, until the pile has reached a moderate height; then fire is applied, and when the whole of the fern is consumed, the ashes are collected and strewn upon fresh beds of fern, which are again fired, and this burning process is repeated five, six, or more times successively—it being held that the more frequently the ashes are burnt, the better is the quality of the product. Some ancient Chinese manuscripts affirm that, instead of fern, the wood of a kind of medlar tree was anciently used; and that the quality of the porcelain was, in consequence, more beautiful. This wood has now become too scarce to be employed for that purpose. The lime and fern ashes are next thrown together into a vessel of water, and she-kao is added in the same proportion as to the creamy dilution of pe-tun-tse. The she-kao dissolves; and the solid matter being separated from the water by subsidence, and removed in a tolerably fluid state, forms what the Chinese call the oil of lime, to the agency of which they attribute all the lustrous appearance of their porcelain. Lime, when uncombined, is infusible, except at a very intense degree of heat, and the fern ashes thus added are essential, acting as a flux, and promoting the fusion of the glaze in the furnace. In mixing these two varnishes together, only one measure of the oil of lime is added to ten measures of that of pe-tun-tse, care being taken that the consistency of both is equal.

When a brighter and finer hue than can be procured from

these oils or varnishes is needed, a mixture of the following kind is prepared: The shores of some of their rivers furnish a species of agate, which is without veins and nearly transparent, so that it approaches the nature of crystal. This stone is calcined to a white powder, and then ground as fine as possible. To every ounce of this they add two ounces of white lead (ceruse), also a fine powder, and after these are mixed with the varnish, the whole is laid on the porcelain the same way as other colors, and it is used as the basis of a variety of colors. Their green, which is prepared from the oxide of copper, is said to be converted into a beautiful violet color by admixture with the white just described. Such a change as this must, of course, be the effect of chemical action promoted by the heat of the furnace. The mere mechanical mixture of white and green would only reduce the depth of its shade. Their yellow is said to result from the mixture, in due proportions, of this white with copperas.

The purification of the two earths having been completed by the processes already described, they are united in the requisite proportions, and these depend upon the quality which it is desired to give to the porcelain. For the finest kind they mix the kaolin and pe-tun-tse in equal quantities, and diminish the proportion of the former according as a coarser kind of ware is required; but for the very coarsest descriptions, the kaolin never forms less than one-fourth the mass.

The most laborious part of the whole operation of the factory is that of intimately kneading and working the earths together, so as to form the two into one homogeneous mass. This is performed in pits, which are paved and cemented, wherein the workmen continually trample upon the paste, bringing together fresh portions by turning it over; and this work is continued without intermission, one set of workmen relieving another at intervals, as each becomes fatigued by the labor, until the mass is thought to be thoroughly mixed, and has been brought to a consistency proper for being moulded by the potter. The mixture is then removed from the pit, divided into small portions, and kneaded by hand upon large slates prepared for the purpose. Too much careful industry can hardly be exercised in this operation. If the

smallest drop of water or globule of air be left remaining in any portion of the mass, the article which contains that portion will infallibly be spoiled by the expansion of the fluid in the oven. The smallest grain of sand, or even a single hair, left in the paste, would be equally prejudicial, occasioning the porcelain to run, or crack, or warp in the baking.

The pieces are fashioned by the Chinese workmen in a manner similar to that adopted in the European potteries, and which has already been described.

Pieces of multiform shape are made in several portions or divisions, which are brought together when used. They are made of yellow unctuous earth, which recurs abundantly in quarries near to the great porcelain manufactory of the empire, and its preparation by kneading and beating is very similar to that bestowed on the porcelain earths. When made and used with care, the moulds last for a long time. The Chinese workmen are not content with the work as delivered from the moulds, but uniformly finish the article by hand, using a variety of chisels and other tools to touch up the various lines and forms given by the mould, as well as to supply its proper deficiencies; so that the potter executes, in some sort, the art of the sculptor. In works where different objects appear in relievo, these are made separately, and added in the way commonly used in other potteries.

Very large pieces of porcelain are made at King-te-ching. These are sometimes of such magnitude that they must first be formed in two, three, or more sections, each one of which requires to be supported during its formation by three or more men. When the different portions are sufficiently dry, they are united with slip, as already described, and the seams are smoothed and polished with an iron instrument, so that, upon their being afterwards covered with varnish, it will not be possible to discern the points of junction.

The labor in the Chinese potteries is divided among a great number of hands, and this is the case with every article made, the most common description of tea-cup. The potter has the management of the wheel, and under his hand the cup assumes

its form, height, and diameter. It is then passed to a second workman, who fits it to its base. From him it passes to another workman, who, by means of a mould placed on a kind of lathe, corrects the imperfections of its shape. A fourth man, by the aid of a chisel, corrects the inequalities and unevenness of the edges, and pares the cup to a substance which renders it sufficiently transparent. In this operation he has frequent recourse to water, in order, by moistening, to prevent the cracking or breaking of the cup. A fifth workman then smooths the inside by turning it gently on a mould. Considerable care is required in this stage to prevent any warping or the formation of any cavity in the cup. Other men then, according to the description of cup to be produced, add either the handle or some ornament in relievo, or make sunken impressions. The operation that immediately precedes the first baking of the cup is that of rounding and hollowing the inside of its foot, which is performed with a chisel.

By this division of labor the work is found to proceed with greater regularity and rapidity; but there is no improvement in the forms or ornaments employed, and the same stereotype shapes have been repeated for generations, without the least modification or change. Their colors are exceedingly lively and brilliant, so that European artists have found it a difficult task to vie with them in this respect; but they are entirely ignorant of perspective, neither have they a knowledge of the human figure, so that their drawings are so many failures. In painting on porcelain,

one artist only forms colored circles about the edges; another traces flowers, which a third paints; a fourth delineates nothing but mountains; a fifth describes water; a sixth traces the outline of birds, which a seventh fills up with colors. Other artists trace and color animals; others again perform the same task with the human figure, and in this way every object of art and nature formed upon their porcelain is the work of a particular artist, who does not attempt the delineation of any other subject. Improvement cannot be expected with such a method of cramping genius within so narrow a compass.

The porcelain first made by the Chinese was of a pure white, and obtained the name of "the precious jewels of jao-tcheou." Blue was the first color with which they ornamented pottery, but the employment of all other colors very speedily followed the introduction of this one. The painting of porcelain with blue flowers is divided into four epochs, all embracing a period between 1426 and 1619; but the employment of blue in painting on porcelain in China is of greater antiquity. The color is produced from a mineral that abounds in all the provinces of the empire. In its native state it is of a blackish-yellow color, but after it is washed and roasted in a porcelain vessel, it is ready for the manufacturer's use. There are two ways of employing it. The first is to dip the vessel into it when the powder has been moistened with water, and the second is to apply the powder dry, by blowing through a tube. Then the glazing is applied. Besides the native blue, the Chinese use cobalt for a fine color, which they receive from Europe. All their colors used for painting are diluted, either with a solution of mastic, with animal size, or with pure water. The first causes the color to flow freely; the second is useful in retouching, while water is employed where the colors are thickest, and also for filling in.

The colors should be capable of fixing themselves to the surface of the porcelain firmly, and of acquiring at the same time, by fusion, the glaze, which is one of the indispensable conditions of the brilliancy of this kind of painting. They are all produced, as has already been stated in treating of European porcelain manufactures, by mixing either an oxide, or a composition of different

metallic oxides, with a vitreous flux, the composition of which varies with the nature of the colors to be developed. The colors are generally obtained by mixing together three parts of the flux with one part of the metallic oxide. Sometimes, as in the case of cobalt, it is necessary that the oxides and the flux should be frittered before being used. Sometimes they are only mixed together, and used as pigments, without being frittered or calcined.

In Europe it is considered especially requisite that these colors should all melt at the same time, and present, after the firing, a sufficient and uniform glaze. The colors of the Chinese paintings do not fulfil these conditions; some are glazed and are very brilliant, while others are dull; some are flat, others are raised above the surface. And besides the great simplicity in design and lack of an artistic element, the general characteristic of the Chinese colors is, that the flux, which is not distinct from the pigment, is always composed of silica, oxide of lead, and a greater or less quantity of alkali. The flux holds in solution a very small portion of coloring matter. The coloring matters are similar to those already described for painting on porcelain.

Besides the white porcelain already referred to, there is a black porcelain, ornamented with gold, and known under the name of umiam, which is much esteemed in the East. The black is produced by mixing three drachms of deep blue with seven drachms of varnish, which they call the oil of stone. The black thus prepared is laid on when the porcelain is first dried, and when the black is also thoroughly dried the vessel is baked. The gold is then laid on, and the piece is subjected to another baking in a furnace peculiarly constructed for that purpose. The gold is ground in water to a very fine powder, and when it has been very gradually dried in the shade, one-tenth of its weight of white lead is added, the mixture is incorporated with gum water, and laid on in the same manner as colors are applied.

Another kind of porcelain, which is in much repute with the Chinese, is called *tsou-tchi*. This has the appearance of having been broken, and the fractured edges brought together and cemented, and then covered with the varnish originally used. This

effect is produced through the peculiar nature of the varnish employed, which never spreads evenly, but has a tendency when in fusion to run into veins and ridges of various and uncertain forms. The varnish is made from a sort of agate stone, reduced by calcination to a white powder, which, after being ground in a mortar, is carefully washed, and used when of the consistency of cream.

Another kind of porcelain, much esteemed by the same people, is called *kia-tsing*, which signifies "pressed azure." Formerly it was produced readily, but the boldest workmen rarely now attempt it. In vessels of this description the colors only appear when it is filled with some liquid. The manner of making porcelain, so as to produce this effect, is as follows: The cup is made very thin, and after having been once baked, the colors are applied in the required form, on the inner surface. When dry, a coating of porcelain earth, the same as that which composes the cup, must be laid on the inside, to be followed by a coat of varnish, so that the colors are enclosed between the two coats or bodies of the ware. The outside, already very thin, is then ground down almost to the painted figures, which are thus made to appear externally, when they must be covered anew with a coat of varnish, so as to be scarcely perceptible from the outside till the vessel is filled with liquid, which acts as a kind of foil and throws out the figures, which would otherwise remain obscure.

Another admired art among this people is, that of producing the semblance of various figures upon pure white porcelain, whose surfaces are yet entirely smooth. A vessel is fashioned extremely thin, out of the best materials, and polished inside and out; a stamp, cut with the requisite figures in relief, is pressed upon the inner surface of the unbaked vessel, over which a coat of the finest white varnish must next be applied, which fills up the cavities made by the stamp, and the smoothness of the inner surface is thus restored. When the ware is baked, the varying thicknesses of the more opaque varnish will be apparent through the sides of the cup, and the whole of the figures will then be seen, as finely and accurately traced as if painted on the outside.

The porcelain transparencies, now so common in this country,

and which are so much admired, come from the Berlin Porcelain Manufactory.

The methods employed by the manufacturers of King-te-ching, in applying the varnish, vary with the different qualities of the ware under operation. For very fine and thin porcelain two exceedingly thin coatings are very carefully applied, and some dexterity is required both in regard to the quantity laid on, and the equal manner of its application. To pieces of inferior quality, as much varnish is applied in one coating as is comprised in the two layers just mentioned. The foot of the vessel is never properly formed until this stage of the manufacture, and after the painting and varnishing have been completed, when this part is finished on the wheel, and varnished likewise, the work is fit to be placed in the oven.

Several reasons are assigned for the high price of Chinese porcelain. One of these is, that owing to their very unscientific manner of conducting the baking process, it rarely happens that some, and frequently a very considerable portion, is not spoiled by unequal or excessive heat, which, in either case, would convert it into a deformed and shapeless mass. Another reason for dearness is, the constantly diminishing supply of the materials used, and more especially of fuel, which becomes very expensive. It is added, that as those pieces which are prepared for the markets of Europe are of patterns not acceptable to the taste of home consumers, and as the factors invariably reject every article which exhibits the slightest defect, either in form or color, the prices paid to the manufacturer for such as are accepted, must be sufficiently high to include the cost of those rejected. But notwithstanding these circumstances, the prices at which porcelain is now furnished in China are materially less than those demanded in ancient times, when, we are informed, a hundred crowns were given for a single urn at the seat of manufacture. The emperor monopolizes the finest specimens of porcelain manufactured in his dominions, and it has hence been asserted, that none of the wares which have ever found their way to Europe give an adequate idea of the perfection to which the Chinese have attained in this manufacture.

The porcelain tower, as it was termed, erected at Nankin, offered proof sufficient of the very durable nature of their manufactures. This building, of an octagonal shape, was of nine stories, and very nearly three hundred feet high. The material of which it was covered, according to the account given by the few travellers who have seen it, was a fine white tile, which, being painted in various colors, had the appearance of porcelain; while the whole was so artfully joined together as to appear like one entire piece. It contained numerous galleries, which were filled with images, and set around with bells, which jingled when agitated by the wind. On the top there was a large ball, in the shape of a pineapple, of which the Chinese boasted as consisting of solid gold. Although this singular and beautiful edifice was erected more than four hundred years ago, it withstood all the alternations of the seasons and every variety of weather, without the slightest appearance of deterioration, and it was but recently that it was destroyed by some of the inhabitants who are distracted by a civil war.

VASES, ETC., IN TERRA COTTA. p. 245.

CHAPTER XV.

TERRA COTTA.

TERRA COTTA—literally baked clay—has been in use from the earliest ages, and is employed alike by civilized and uncivilized nations. We find it in the debris of Grecian cities, amid the heaps of ruins of those of ancient Egypt, and beneath those of Aztec and Mexican cities. Innumerable specimens have been brought to light in such places, some of them bearing unmistakable evidence of having been dried in the sun, the only mode of hardening tiles in the earliest ages; others have been baked, and again samples that were evidently colored after the baking, and even richly gilded, have been exhumed. The Chaldeans were in the habit of interring their dead in coffins of baked clay, covered with green glaze, and embossed with figures of warriors dressed in a short tunic, and long under-garments, a sword by their side, their arms resting on their hips, and their legs apart. Ornaments of gold, silver, iron, copper, glass, &c., have been found around these receptacles of the dead, and occasionally inscriptions of a very early date.

The date of the original production of Etruscan vases, extant, is from the second to the fifth century of the Christian era. Their forms bear conclusive evidence of the grace and beauty with which a refined and cultivated intelligence can mould even the objects which minister to our daily wants and comfort. Opposite we give a design for a circular plateau, designed for a table top, in the style of the Etruscan.

Nearly all the ancient specimens of pottery, and those of the middle ages, are earthenware, and it was not until the introduction of flint and felspar into the materials of the potter, that any true stoneware could be said to have been produced. From the time of the Roman rule in Europe, until the middle of the fifteenth century, pottery, as an art, seems to have attracted but little attention. Its first influence was derived from Tuscany, where the sculptor, Luca Della Robbia, whose works present the closest alliance of sculpture with pottery, somewhere about 1415-20, employed a stanniferous glaze as a coating to his terra cotta; and it was in his factory that the designs of Raphael were copied, and which have imparted his name to the ware.

Modern terra cotta differs from articles of ancient wares of this description, in that it is much more durable. The finest clays are used, and these must be free from the oxide of iron. The clay is combined with calcined flints and crushed pottery, and baked at a temperature little below fusion. When the materials are good, the ware is of a rich rose color. The French have an advantage over the English manufacturer, in the possession of a clay of a beautiful tint, which they call "kaolin rose." It is remarkable for its purity and extreme delicacy. With this they are enabled to copy the old Samian pottery, common to the ancient Gauls, of which they possess admirable specimens.

The several operations through which terra cotta passes, while

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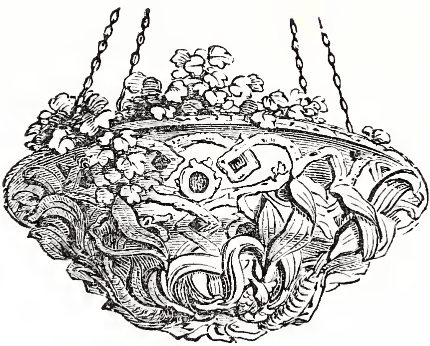
ETRUSCAN TABLE TOP. p. 247.

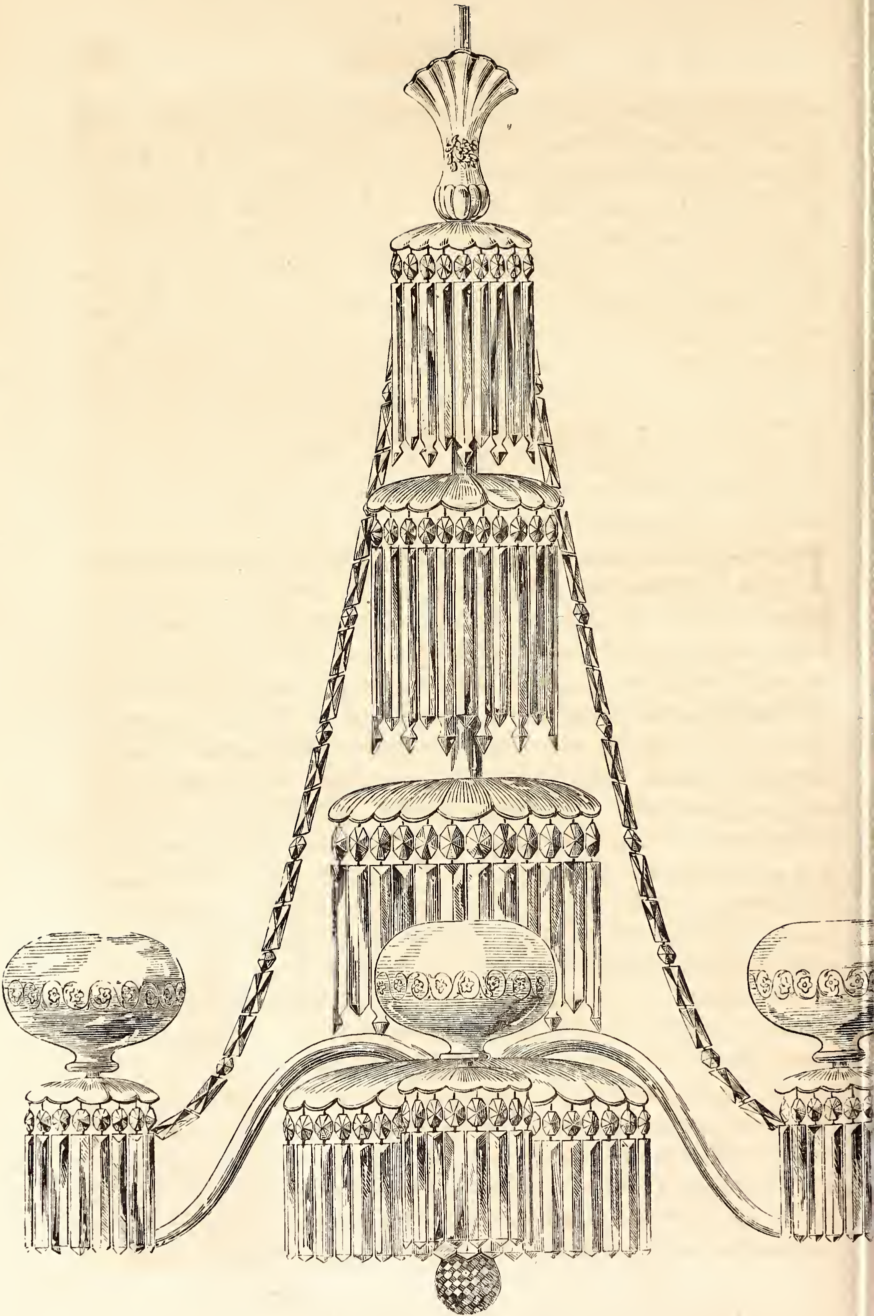
in the course of manipulation, renders it impervious to the weather, and capable of sustaining great heat; it is therefore admirably adapted for ornamental building purposes. Architectural decorations are made of it, in the form of cornices or wash-boardings, centre-pieces for ceilings, and many other decorative purposes, to which wood carving or stucco has been hitherto applied. These ornaments are entirely fire-proof, and may be painted, if their color is not agreeable, to imitate wood carvings. And it is not necessary that they should be inserted when the building is erected, for they can be fastened to the walls at any time, by means of screws or liquid plaster. The whole of the grand façade of the Spedale Maggiore (the great hospital) at Milan, is made of bricks moulded into a variety of forms—graceful festoons, cornices, medallions, architraves—all of brick, and of different tints.

We have given an illustration of its qualification for architectural ornaments (which may be readily and cheaply moulded) in the form of a Corinthian capital, of American workmanship. Decorations of this description, when properly made and baked, will wear well and become impervious to the weather. The most delicate details can be readily wrought in clay by skilful hands; the material is readily obtained, and it requires only to have its qualities more fully appreciated to come into general use. Bricks of the common red clay, or any other variety of clay, are now coated with glass, to a degree that insures durability and entire resistance to moisture, imparting at the same time an ornamental appearance to the front of buildings made of them. The form of the brick is also made, by means of grooves at the side and ends, to add greatly to the strength of the edifice; the joints are brought closer, and from the shape of the groove the mortar acts as a dowel.

Terra cotta has also been successfully employed in modelling rustic figures, single and in groups, and many of them are full of touching beauty and thoughtful expression. We lose sight of the material entirely, and look only at the artistic merit of groups like the one here presented. The finest sculptured vases of the antique are likewise carefully modelled after the originals, or with modifications. One of these, embellished with a design from the

Elgin marbles, we have given in another page. And more humble objects, finished to a degree that is full of promise, are now brought to our notice. Of these we may speak of the beautiful hanging baskets, an article hardly known out of France a few years ago, but which now may be seen in every conservatory, and often in the recesses of our parlor windows.





GLASS CHANDELIER.

CHAPTER XVI.

GLASS.

THE Egyptians are said to have been taught the art of making glass by Hermes. Pliny says the discovery of glass took place in Syria. Glass houses were erected in Tyre, where glass was a staple manufacture for many ages. This article is mentioned among the Romans in the time of Tiberius, and we know, from the ruins of Pompeii, that windows were formed of glass before A. D. 79. Italy had the first glass windows, next France, and England followed, where imported panes were used in private houses in 1177. The manufacture of glass was established in England at Crutched-friars, and in the Savoy, in the year 1557. It was improved in 1635, and was brought to great perfection in the reign of William III. The first attempt to establish the manufacture in this country was in 1790. Of subsequent and more successful efforts we shall have occasion to speak hereafter.

The origin of glass-making is lost in the shades of antiquity, so remote that it is not easy to distinguish fable from history. To the former most certainly belongs the absurd legend, so often quoted from Pliny, that glass was first formed accidentally by Phœnician dealers in native soda, who, halting on the shore of the river Belus, and resting their kettles over the fire upon lumps of soda, caused the sand of the shore to form glass with the alkali. A single fact is worth all the speculation which ingenuity can invent, and such an one is supplied by the researches of Lay-

ard among the ruins of Nineveh, where he found a perfect and beautifully formed vase of glass, now in the British Museum. It bears the marks of having been turned in a lathe, a process never attempted in our time. The maker's name is also engraved on its foot, and the circumstances attending its discovery authorize the belief that it dates at least seven centuries before the Christian era. The same indefatigable antiquarian has also discovered in the ruins of the same city a convex lens of rock crystal, proving that the ancient Assyrians were, to some degree, familiar with the properties of light, as well as with chemistry.

The fact is, glass and porcelain, equal in quality to that in use at the present day, were made 1600 or 1700 B. C. in Upper Egypt. The glass blowers and glass cutters of Thebes imitated amethysts, rubies, and other precious stones, with wonderful dexterity, specimens of which are to be found in all the museums of Europe; and besides a great proficiency in the art of staining glass, they must have been aware of the use of the diamond in engraving and cutting it. False emeralds of considerable size have repeatedly been brought to light, and the obelisk of emerald made mention of by Pliny (sixty feet in height), in the temple of Jupiter Ammon, was of glass, colored by the oxide of copper. And granite sarcophagi, covered with a coating of stained glass, through which the hieroglyphics in the stone appear, have been exhumed. Glass bottles of Egyptian workmanship, resembling in shape the wide-mouth bottles used in preserving fruit, and similar to our wine bottles in color and measure, are to be seen in the cabinets of Europe. The Florentine oil flasks, and the turpentine carboys, as they are called, from the shores of the Levant, are precisely of the form of bottles from Thebes. Both are protected by matting, and such was the custom with the ancients. Magnifying lenses they must have had, for some of their cameos extant could not have been cut without the aid of the microscope. In the Egyptian room of the British Museum there is a tablet of stained glass, found at Thebes. The design is described as tasteful. It consists of a quadruple star with a rose in the centre, and with foliage in the angles. Blue, yellow, red, and green colors are introduced, and they are struck through the glass. In order

to produce this effect of glass-staining, oxides of cobalt, or calcined copper and zinc, must have been used for the blue, oxide of silver for the yellow. The ruby color of the rose—that color, of which, till lately, we had lost the art of imparting—must have been given, as well as the rich purple hue of some of the gems, by the oxide of gold. They certainly attained to great proficiency in the preparation of their pigments, and their painted walls still bear evidence of their skill in this particular. On those that are still preserved, glass blowers are represented forming bottles of green glass. Those in the British Museum have long necks, and bulge out towards the bottom. Pocket bottles, cased in leather, after the manner of preparing them for sportsmen, they were in the habit of making, and they understood the curious process by which a bird or flower may appear to be imprisoned within a piece of glass, so as to form a part of its own substance. It appears they constructed the device from filaments of colored glass, in the first instance. It was then covered with transparent laminæ of glass, and all were fused together with so much skill that no joint in any part of the glass can even now be detected by the most powerful magnifier. In these specimens the colored device appears as perfect on one side as on the other. Figures of birds, when thus composed, if cut through at intervals, each portion so divided will be found to contain in itself a perfect bird. The celebrated Portland vase was long supposed to be a real sardonyx, but it is now found to be formed of layers of purple-colored glass, united by fusion. It is ornamented with white opaque figures in bas-relief. The whole of the blue ground, or at least that part below the handles, must have originally been covered with white enamel, out of which the figures have been sculptured in the style of a cameo with most astonishing skill and labor.

It is a curious fact in the history of discoveries, that the manufacture of glass was, a few years since, unknown on the spot where it is reputed to have been invented by the Phœnicians.

The Phœnicians and the Egyptians introduced their art into Sicily, the islands of the Archipelago, and Etruria, and it appears

certain that manufactories of glass vessels were established in these countries at a very remote period.

According to some authors, glass was not imported into Rome until the time of Sylla, after the conquest of the Republic in Asia, and when the art of glass-making had already made considerable progress. It immediately rose in high estimation. Augustus, having subdued Egypt, required that glass should form part of the tribute of the conquered. This tribute, far from being a burthen upon the Egyptians, proved a source of great advantage to them. Glass became so much in fashion that considerable quantities were imported to Rome. In the reign of Tiberius, manufactories of glass were established in the neighborhood of the great city, and this competition naturally awakened the emulation of the glass-makers.

The Romans soon discovered the method of staining glass, of blowing it, of working it on a lathe, and of engraving it. They knew how to make cups of glass as pure as crystal, and Pliny informs us that Nero paid, for two of small size, six thousand sestertia. The taste for vessels of glass was carried to such an extent, as to cause them to be preferred for use to vessels of gold and silver.

Nero, Adrian, and his successors, down to Gallienus, all patronized the art of glass-making. This last took a dislike to glass, and would drink only out of vessels of gold, but the manufactories of glass, which, under this emperor, began to decline, were restored under Tacitus, who granted to the glass-makers his especial patronage.

The early Christians were acquainted with the art of decorating vessels of glass, and large quantities have been found in the catacombs, and in some of the cemeteries of Rome, enriched with various ornaments.

When Constantine removed the seat of the empire to Byzantium, he was not satisfied with carrying off the masterpieces of art from Rome, Greece, and Asia, to adorn his new capital; but he also summoned thither the most celebrated artists of every description. Manufactories of all that luxury could desire, soon rose in the neighborhood of this opulent city.

A severe shock was, of necessity, given to the industrial arts by the invasion of the barbarians, the pillage and burning that Rome had several times to undergo, and the miseries which overwhelmed Italy for many centuries. The art of glass-making appears to have suffered more than any other, and if some manufactories continued to exist in Italy, their productions must have been confined to common glass, intended only for domestic purposes. Ornamental pieces, or those vases of colored glass, in layers of different shades, enriched with carvings and skilful decorations, which, for many centuries, had been the pride and admiration of the Romans, these Italy had to produce. The decorative artists in glass had found refuge in the empire of the East, and the Greeks alone were, for a long period, in possession of the manufacture.

Theophilus, the Monk, who described the industrial arts of his time, devoted the second book of his treatise to an explanation of the processes of the manufacture of glass, of the making and decoration of the vessels that can be made of it, as well as of the painting of glass windows. And when he comes to speak of ornamental vases, of those vases of glass embellished with incrustations of gold, with paintings in colored enamel, and with ornaments in glass filagree, it is to Greeks alone that he attributes the manufacture. They also made several kinds of vessels with different sorts of glass. Of these were cups made in opaque glass, the color of sapphire, which was capable of three kinds of decoration. The first consisted in cutting out, in rather thick gold leaf, human figures, animals or flowers, which were fixed upon the cup with water; very clear glass, like crystal, fusible at a low temperature, was then, after having been ground with water on a porphyry stone, laid on very thinly over the gold leaf with a pencil. When the preparation was dry, it was placed in the furnace used for firing the painted glass windows. The wood was withdrawn from the furnace as soon as the heat had sufficiently penetrated the cup to produce a slight tinge of red.

The second manner introduced by the Greeks, for the decoration of cups of opaque sapphire glass, consisted in enriching them with subjects of ornaments composed of gold or silver ground in

a mill, tempered with water, and laid on with a brush. The metallic preparation was covered over with the thin layer of clear glass already mentioned. By another method, the design was expressed with enamels of the same nature as those used in incrustations. The different enamel colors were ground separately upon the porphyry stone, laid on with a brush, and fixed upon the glass by vitrification in the furnace used for window glass, in the same manner as the cup before described. They also made cups and flasks of a bright transparent glass, of a sapphire and purple color, which they enriched with a network of white or colored glass filagree, to which they added glass handles of the color of the network. Thus the Greeks of the Lower Empire, from what Theophilus says, had not only preserved all the fine processes belonging to the glass-making of antiquity, but they also had discovered others, consisting of the use of painting in vitreous colors, an ingenious method which the ancients do not appear to have practised.

If, however, the Eastern Empire appears, until towards the close of the fourteenth century, to have been exclusively in possession of the manufacture of ornamental glass vessels, a powerful rival had nevertheless arisen, who was soon about to snatch from it this branch of artistic industry.

In the course of the eleventh and twelfth centuries, the city of Venice had become the most commercial of the civilized world. She had above all established her power by means of navigation and trading to the East. In the thirteenth century, the profits she derived by transporting the commodities of other nations no longer satisfied her ambition; to commerce she was desirous of uniting manufactures. Accordingly, many new ones were set on foot, as well at Venice itself as in the States of the Republic on Terra Firma, and those which already existed received a lively impetus, and were very considerably developed.

The glass manufactories, to believe the Venetian authors, were almost contemporaneous with the founding of the city itself. A great event which marked the beginning of the twelfth century, was the means of increasing their prosperity, and contributed to the introduction of art into a manufacture until then

purely industrial. The Venetian republic had, in short, participated in the taking of Constantinople, by the Latins, (1204,) and, imbued as she was with the spirit of commerce, she sought to derive every possible advantage of this victory in favor of her dawning manufactories. The glass-houses of the Eastern Empire were inspected by agents of the republic, and Greek workmen were allured to Venice. It is certain, that to date from the end of the thirteenth century, an uninterrupted series may be produced of acts of the Venetian government, which prove both the importance of the glass manufactories of that remote period, and the special interest ever taken by the state in the cultivation of the art, which, to use the expression of a Venetian writer, it guarded as the apple of its eye. In this it displayed great sagacity; since, for many centuries, the four quarters of the world were inundated by the various productions of the glass manufactures of Venice, and the sums of money procured to the Republic by this branch of industry alone, would utterly defy calculation.

From the end of the thirteenth century, the manufactories of glass had so multiplied in the interior of Venice, that the city was incessantly exposed to fire. A decree of the Great Council, in 1287, prohibited any manufactory of glass to be established within the city, unless by the proprietor of the house in which it was to be carried on. This exception in favor of the proprietors perpetuating the inconveniences which the government had endeavored to guard against, a new decree was issued, by which all the manufactories of glass still existing in the interior of Venice were ordered to be demolished and removed out of the city.

It was then that choice was made of the island of Murano, which is only separated from Venice by a canal of small extent, for establishing in it the manufactories of glass. In a few years, the whole island was covered with glass-houses of various descriptions. Subsequently the manufactories of small glass-ware, for the making of beads, false stones, and glass jewels, were allowed to be set up in the very interior of Venice, with the sole condition of their being insulated at least five paces from any habitation.

This favor granted to glass jewelry proceeded from the immense trade in it carried on by Venice at that period, and the government was careful in no way to check a branch of industry which extended its relations in Africa and Asia, and consequently favored the extension of its navy, upon which depended the increase of the power of the republic.

The invasion of the Eastern Empire by the Turks, and the taking of Constantinople in 1453, which occasioned the immigration of so many artists into Italy, was beneficial to glass-making, as well as to other industrial arts. To date from the fifteenth century, we find the manufacture of glass vessels taking a new direction. The Venetian glass-makers borrowed from the Greeks all their processes for coloring, gilding, and enamelling glass; and the Renaissance having restored a taste for the fine forms of antiquity, the art of glass-making followed the movement given by the great artists of that period, who rendered Italy illustrious; and vases were produced in no wise inferior in form to those bequeathed by antiquity.

At the end of the fifteenth century, or rather in the first years of the sixteenth, the Venetian glass-makers distinguished themselves by a new invention, that of vases enriched with filagrees of glass, either white or colored, which twisted themselves into a thousand varied patterns, and appeared as if incrusted in the middle of the paste of the colorless and transparent crystal. This invention, which, while it enriched the vases with an indestructible ornamentation, preserved at the same time their light and graceful forms, gave a new impulse to the manufactories of glass ware, and caused their beautiful productions to be even more sought after by every nation of Europe. Accordingly the Venetian government used every possible precaution to prevent the secret of this new manufacture from being discovered, or Venetian workmen from carrying away this branch of industry to other nations. A decree went forth, prohibiting the exportation, without the authority of the state, of the principal materials in the composition of glass, and the superintendence of the manufactories of Murano was intrusted to the chief of the Council of Ten, and subsequently the Council reserved to itself the care of

watching over the manufactories, to prevent the art of glass-making from being carried abroad. Yet all these precautions did not appear to have been sufficient, and the inquisition of the state, in the twenty-sixth article of its statutes, announced the following decision: "If a workman transport his art into a foreign country, to the injury of the republic, a message shall be sent to him to return; if he does not obey, the person most nearly related to him shall be put into prison. If, notwithstanding the imprisonment of his relatives, he persist in remaining abroad, an emissary shall be commissioned to put him to death." Two instances are recorded of the execution of this punishment on some workmen whom the Emperor Leopold had enticed into his state.

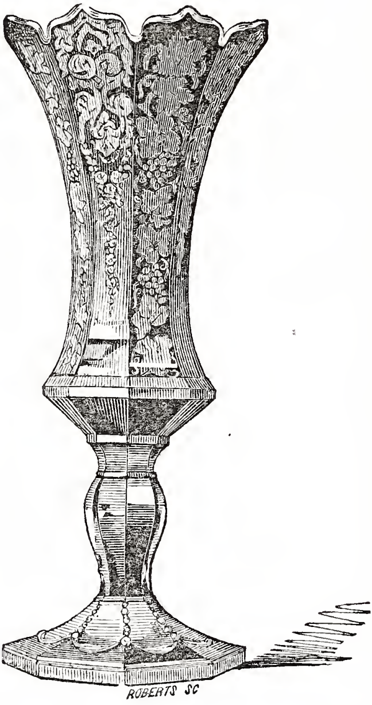
If the government of Venice thought it needful, on the one hand, to display all its severity against the glass-makers, who should thus betray the interests of their country; it, on the other hand, loaded with favors those who remained faithful to its service, and great privileges were accorded to the island of Murano. From the thirteenth century the inhabitants obtained the rights of citizens of Venice, which rendered them admissible to all the high offices of state; and the senate subsequently granted them the right of electing a chancellor to administer justice in Murano, and a delegate to the Venetian government, to treat of matters which interested the community.

The glass-makers were not classed among the artisans; they received as well from the senate of Venice as from several foreign sovereigns, many privileges remarkable for the age in which they were granted. Thus, the noble Venetian patricians might marry the daughters of the master glass-makers, without derogating in any manner from their dignity, and the children born from these marriages retained all their quarterings of nobility. And when Henry III. went to Venice, in 1273, he granted nobility to all the master glass-makers of Murano.

Protected by severe laws, invested with great privileges, and encouraged by honorable distinctions, the manufacturers of Murano were thus elevated to the rank of distinguished artists. Their enamelled vases of the fifteenth century, their graceful cups

and ewers, and filagree ornaments of the sixteenth century, were in no wise inferior as regards either form or decoration to the finest productions of antiquity, and all Europe became their tributary during two hundred years.

At the beginning of the eighteenth century, the tyrant fashion, which causes the most beautiful objects of art to fall into disrepute, made the glass-ware of Bohemia—glass cut in facets—alone to be sought after, to the great detriment of the beauty and lightness of the forms. Some manufactories in France and England began to yield fine productions in cut glass, and the Venetian glass-ware, with filagree ornaments, gradually fell into disuse. The fall of the Venetian republic, the abolition of the privileges granted to the glass-makers, and of the rules which governed their corporation, gave the last blow to the art of glass-making at Venice, and the manufactories which still existed at Murano, soon confined themselves to producing domestic utensils in common glass.



The manufacture of glass ware with ornaments in filagree or in colored threads, is no longer a secret, and now that collectors have drawn attention to its merits, imitations have been attempted by many manufacturers, who, without having yet attained to the lightness and perfection of the forms of the sixteenth century, have still introduced into commerce glass of much elegance. The process necessary for the manufacture of these will be described in another chapter.

CHAPTER XVII.

GLASS

THE glass of commerce is always composed of some siliceous earth, the fusion and vitrification of which has been occasioned by certain alkaline earths, or salts, and sometimes with the aid of metallic oxides. The different varieties are known as flint glass, or crystal; crown, or German sheet glass; broad, or common window glass; bottle, or common green glass, and plate glass. Each of these five descriptions contains, in common with others, two ingredients, which are essential to its formation—silex and an alkali. The variations of quality and distinctive differences observable in glass, principally result from the kind of alkali employed and its degree of purity, as well as the addition of other necessary materials, such as nitre, oxide of lead, or of manganese, white oxide of arsenic, borax, or chalk. Sea sand, which consists of spherical grains of quartz, so minute as to be qualified for the purpose without any preparation except careful washing, is the form in which silex is most commonly used for the purpose. The best glass was formerly made with common flints, calcined and ground in the manner already described as used in the manufacture of pottery, and hence the name which it has acquired, of flint glass. The employment of silex in this form is now wholly discontinued, as it is known that some kinds of sand answer equally well, while the name is retained.

Both soda and potash are well adapted for the purpose of making glass. They are used in the form of carbonates; that is,

holding carbonic acid in combination with themselves as basis. The acid flies off during the process of manufacturing, and the result is a compound of silex and alkali. For the finest flint glass, pearlash, which is potash in the purer form, is used. Coarser kinds of alkali, such as barilla, kelp, or wood ashes, which are combined with many impurities, are employed in the production of inferior glass. The green color imparted to glass is produced by the iron, which is present in a greater or less degree, in the coarser alkaline substances. This may be removed by using the black oxide of manganese. When added in a moderate proportion to any simple glass, it imparts a purple color, and should the quantity be much increased, this color is deepened until the glass becomes nearly black. If, while the mass thus colored is in fusion, either white arsenic, or charcoal, or other carbonaceous matter be added, an effervescence is seen to follow, and the color becomes gradually more faint, until it altogether disappears and the glass is rendered clear and transparent.

Borax is used only in preparing the finest descriptions of glass, and is confined principally to plate glass, causing the compound to flow with great freedom, and to be without speck or bubble, which would impair both its beauty and utility.

Lime, in the form of chalk, is useful as a very cheap flux. It is also beneficial in facilitating the operations of the workmen in fashioning glass, and it has the property of diminishing its liability to crack on exposure to sudden and great variations of temperature. But when it is in excess the glass is rendered cloudy.

Three different kinds of furnaces are employed in the manufacture of glass. The calcar, used for the calcination of the materials previous to their complete fusion and vitrification, the process of which is called fritting. The working furnace, wherein the frit, when placed in the glass pots or crucibles, is fully melted and converted into glass; and the annealing oven or lear, for tempering glass, and in which the crucibles intended for future use are dried.

Flint glass, known also as crystal, is the most beautiful of all the vitrified compounds that are manufactured. It is the most easily fashioned by the workman, and it has the greatest refrac-

tive power; but for all purposes it cannot be used. If a vessel of flint glass be filled with carbonate of ammonia, it will soon be rendered brittle, and the slightest cause will occasion it to fall in pieces, an objection that cannot be urged against the common green bottle glass.

The properties of flint glass, which distinguish it from other vitrified substances, are owing to the presence of some metallic oxide. All metals when oxidated will combine with silica and alkali, to form glass. Few of these, however, are properly qualified for the purpose, in consequence of their imparting color to the mass. The oxides of lead and bismuth are the only two which may be used in sufficient quantity without producing this inconvenience; and as lead is much the cheapest of these metals, the preference is always given to it in the manufacture, while an over-dose even of lead will destroy the purity of the glass, imparting to it a yellow tinge. There are various proportions used in the manufacture of flint glass. One rule is, to combine white sand, red lead, pearlash, and a small percentage of nitre and oxide of manganese; another requires the use of the same materials, substituting oxide of arsenic for the nitre and manganese.

When the ingredients are intimately mixed, they are cast, by means of clean iron shovels, through the side opening of the furnace into the crucibles, which have been brought to a white heat. The pots are filled at once with this mixture, but as the bulk of it decreases materially in melting, a fresh portion must be added when this effect has been produced, and this operation is continued until, by these successive fillings, the vessel at length becomes sufficiently charged with melted glass. Before any fresh portion of materials is added, the contents of the crucible must be completely melted. The contents are soon observed to sink down in the state of a soft paste, and ere long become perfectly melted, when it throws up a scum, which, when removed, leaves a perfectly transparent glass. But a long continued and powerful heat is required before all the impurities are discharged. Forty-eight hours from the first charging of the crucibles, is the usual time required for the fusion and perfect refining of flint glass.

When cooled to the proper heat for working, the glass has

lost its perfect fluidity, and forms a consistent and tenacious mass, soft enough to yield to the slightest external impression, yet capable of being pulled and fashioned into all imaginable shapes, without cracking or parting with its tenacity; so that, if in this state it be stretched or drawn out, it will preserve the form of a solid fibre, constantly decreasing in its diameter, without separating until reduced to the merest filament. When no longer heated to redness, it becomes rigid, brittle, and transparent. During the whole time of working a pot of glass, which varies from five to twenty hours, and in some instances even a longer period, its consistency should be maintained as nearly as possible at the same point; and to succeed in this, calls for considerable attention on the part of the workmen.

The implements used by the glass-blower are few in number, and exceedingly inartificial in their construction. The principal one is simply a hollow iron rod, or tube, about five feet long, upon the end of which the workman collects the quantity of melted glass that will suffice for forming the article intended. In this operation the rod is dipped into the pot and turned about several times. If the size of the vessel requires a considerable weight of glass for its formation, the rod is taken out and exposed for a moment to the current of air, by which means the surface of the glass already collected is sufficiently cooled for a fresh portion to adhere, and this process is repeated until enough is collected for the object.

When the rod, thus loaded, is withdrawn from the crucible, it is held for a few seconds in a perpendicular position, the end to which the glass is attached being nearest the ground, that, by its own weight, the mass may be lengthened out beyond the rod. Then the glass is rolled on the flat surface of a smooth horizontal iron plate, called the "marver," by which means the particles of glass are agglomerated in a cylindrical form. The workman now applies his mouth to the other end of the tube and blows strongly through it, so that his breath penetrating the centre of the red-hot glass, causes it to distend the sides till the proper size and thickness are attained. To elongate the globe the effect is produced by giving to the rod, while the glass attached to it is soft-

ened by heat, an alternate motion, similar to that of a pendulum, or by dexterously making it perform a circle swiftly through the air.

At this stage another instrument, called a *punt*, is brought into use. This is a solid iron rod of a cylindrical form, smaller and lighter than the tube used for blowing, and consequently more within the power and management of the workman. Upon one end of this rod a small portion of melted glass is collected from the crucible by an assistant, and in this state it is applied to the surface of the globe, on the side opposite to that where it is already attached to the tube. The two substances speedily uniting, the glass is detached from the hollow rod, by touching it near to the point of contact with a piece of iron dipped into cold water. This occasions the glass to crack; so that, by giving a smart stroke to the hollow rod, it is immediately and safely separated, leaving a small hole at the point of rupture.

From the attendant the workman receives the punt with the glass vessel attached, and after reheating it at the furnace mouth, as before, he seats himself in a sort of stool provided with arms sloping forward, whereon the punt is supported before him in a horizontal position, the glass being at the man's right hand. Thus placed, he governs with his left hand the movement of the punt, by twirling it to and fro along the arms of the stool, and taking in his hands an iron instrument, much resembling a pair of sugar tongs in form, he enlarges or contracts the vessel in different places until it assumes the required form. All superabundance of material is cut away by the scissors, while the glass is red-hot, with as much ease as one could divide a piece of soft leather.

To insure the requisite regularity in size and shape, the workman is provided with compasses and a scale marked off into feet and inches. The finished article is detached from the punt, or pontil, as it is also called, as before described, by wetting it with cold water at the point where it is attached to the rod, when it drops gently on a bed of ashes kept at the man's side for the purpose. It is then conveyed without loss of time, and still exceedingly hot. to the annealing oven.

A glass shade has been blown in Birmingham, sixty-two inches by twenty-six and a half inches in diameter, containing nearly forty pounds of glass.

A secret in blowing great glass bubbles was lately described in the London Builder. It consists in simply moistening the mouth with a little water before blowing. The water is converted, in the interior of the drop, into steam, which greatly aids the breath in the extension of the "bell."

If it be required to give to the article any form or pattern unattainable by the simple means narrated, a mould is provided, into which the glass is placed and blown, and in this way it receives the requisite impression as readily as wax. To form a tumbler in this way a mould of solid brass, about as large as a half-peck measure, and containing a hollow in it exactly of the form of a tumbler, is prepared. It has also a follower of brass of the same form, but so much smaller as to fit the inside of the tumbler. When the two parts are put together the space between them is of the exact thickness of the vessel required. In the process of manufacturing, three men and two boys are required. The first man dips an iron rod in the melted glass and moves it about until he has gathered a sufficient quantity of the fluid mass; he then holds it over the hollow of the mould, and with a pair of shears cuts off what he judges to be just enough to constitute the tumbler. Instantly the next man brings down the follower with lever power, and the melted glass is so compressed as to fill the cavity of the mould, which he then turns bottom up, with a little blow, and the tumbler drops red-hot upon the stone table. One of the boys, with an iron rod having a little melted glass on its end, presses it on the bottom of the tumbler, to which it slightly adheres. He then holds the tumbler in the mouth of a glowing furnace, turns it rapidly till it is almost in a melted state, when it is passed to a third man, who whirls the rod and tumbler in a sort of arm-chair, at the same time removing all the roughness of the edge by means of a small iron tool. From him the rod passes to another boy, who separates from it the tumbler, which he places in the annealing oven. In this way these

GLASS VASES.

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five hands will produce a beautiful tumbler in about forty-five seconds.

But pressing hot glass into metallic moulds, an art which has been considered a modern discovery, was evidently understood by the Egyptians, as specimens of glass coins with hieroglyphical characters, and other similar works, attest. The Romans were also in the habit of pressing colored glass into the form of brooches, rings, beads, &c.

The process of annealing is one of great importance, as, without it, glass will be liable to crack and fly with the smallest change of temperature, and would break with the merest scratch or touch, and even without any apparent external cause of injury. Articles newly made are placed in the shallow trays of the annealing oven, and so arranged as to be exposed to the heat of the fire, which is kindled under one end only. Each one of these lier pans, as it is filled, is pushed forward towards the colder end of the oven, to make place for a fresh tray, until the articles at length, and in succession, reach the other extremity, whence they are taken out, but little warmer than the temperature of the atmosphere. By the gradual manner in which they have parted with their heat, time has been allowed for the gradual contraction of the whole into a uniform and consistent substance. Glass, which is afterwards to pass through the hands of the cutter, is always made of considerable thickness, and requires not only that the heat of the oven should range high, but that it should also be withdrawn very gradually; while, on the contrary, such articles as are very thin may be placed first in a moderate temperature, to be removed altogether from the influence of the fire at the expiration of a few hours.

The name of "crown glass" is given to the best kind of glass used for making windows, and like purposes. In its composition no lead or metallic oxide enters as a fluxing agent. A small quantity of manganese is frequently used, and sometimes also a minute portion of oxide of cobalt, but the object of these additions is, the correction of the faulty color in the glass, arising from the impurities in the sand and alkali. This kind is therefore much harder than flint glass, and would consequently be

more difficult to fashion in any other form than that of a plane surface.

When the materials are properly fused and refined, the workman takes it from the pot on the end of the tube, and blows it into form, after a manner similar to that already described, when the side opposite the tube is flattened by pressure against a plane surface; then a small portion of melted glass is collected on the end of a punt and applied to the end of the flattened side, forming a union with it exactly opposite to the hollow tube, which is then removed by wetting the glass near to the point of union, leaving a circular hole in the glass about two inches in diameter. To continue the operation it must now be heated again, when the workman dexterously twirls the punt in his hand, slowly at first, and then more and more quickly, when the glass yields to the centrifugal impulse, its diameter becomes greater and greater, the hole referred to expands proportionally, and when in this continued progression the double portion opposite to the end of the rod and between the periphery of the glass and the orifice is diminished to an annulus or ring only a few inches wide, then, in an unaccountable manner, it instantly flies open and the glass is converted into a plane disc of fifty or sixty inches in diameter, having a uniform thickness throughout the plate, with the exception of the spot where it is attached to the iron rod, where a knot or lump is formed, called the bull's eye.

The plate thus finished, is detached from the rod in the usual way, and placed on its edge in the annealing oven, where some considerable degree of care is necessary to regulate the heat to which it is exposed, as too much would cause it to bend and settle down, and if the oven be not sufficiently heated the plates are apt to crack.

"Broad glass" is a common, coarse description of window glass, made of inferior ingredients, and by a somewhat different process than that of crown glass. The sheets are thus prepared. The necessary quantity being collected on the end of the tube, is expanded by the workman into a globular, or rather into an elliptical shape, of about twelve inches in diameter, and of the requisite thickness. This done, the glass is carried to the oven's mouth,

and the end of the tube, through which the workman has blown, being closed, the farther expansion of the confined air causes the glass to burst in its weakest part. While still hot and ductile it is opened its entire length, by a pair of shears, into a flat plate, which is then carried to the annealing oven.

The composition of "bottle glass" is as little uniform as that of any other description of the material. It is usually made of sand, lime, and sometimes clay,—any kind of alkali or alkaline ashes, which may happen to offer the greatest inducement in the point of price, and sometimes the vitreous slag produced from the fusion of iron ore. Soap-makers' waste is frequently used in the proportion of three to one of sand. The impurity of the alkali, and the abundance of a fluxing material of an earthy nature, joined to the very high degree of heat at which they are fused, occasion the glass to contain a very small proportion of real saline matter, for which reason it is better adapted than flint glass to contain fluid which has a corrosive action. Articles made of bottle glass are fashioned by the same process as those of flint glass, with the exception of wine and beer bottles, the containing parts of which are blown in metallic moulds, in order to keep them nearly of a uniform size.

If, during the time the workmen are employed in blowing and moulding bottles, the melted glass becomes cooler than is desirable for the purpose, so that it be found necessary to replenish the fires, so much dust will be thus occasioned that the surface of the glass will be covered with carbonaceous matter, and the glass, which had before remained perfectly quiet, becomes suddenly so disturbed throughout, as to present the appearance of violent ebullition, and the whole mass is immediately covered with an infinite number of minute air bubbles, which, so long as they are suffered to remain, render the glass wholly unfit for use. Whenever this occurs, the workman has only to throw a small quantity of water into the crucible, when the whole mass will immediately be stilled, and the bubbles will as instantly disappear, so that he may proceed without further delay. This curious effect has been referred to the decomposition of the water by heat, which, giving up its oxygen to the coal dust, converts it into carbonic acid gas,

in which form it is instantly driven off by the excessive heat of the furnace.

Two descriptions of plate glass are made: one by opening, after the blowing, in the manner of broad glass, already described; the other, by casting the melted materials upon a plane metallic surface, somewhat in the manner pursued in making sheet lead.

Plates of glass which are blown are necessarily limited in their size, although some of considerable dimensions are produced in this way. Glass melted and run into plates for windows, is said to have been introduced A. D. 422. The real discovery of the process was accidentally made by a workman, who spilt the contents of a crucible of molten glass on the floor of the glass-house, some of which ran under a flat stone, which, when he raised it to collect the glass, disclosed a perfect plate, far superior to any thing that could be produced by blowing. This occurred about 1498, and the man could not rest till he had successfully carried out the idea thus happily presented.

When cast, the extent of the plate is limited only by the very heavy expense attending the erection of the machinery and the prosecution of the manufacture in its various parts. More care in the choice of materials, and greater nicety in conducting the processes, are required for the preparation of plate glass, than are needed in any other branch of the manufacture. The materials employed are sand, soda, and lime, to which are added manganese and oxide of cobalt, as decoloring substances. The sand must be of the purest and whitest kind, and must be passed through a wire sieve of the proper closeness, into water, to free it from all impurities. The alkali used is always soda, which is preferred to potash, as glass made with the former substance is thinner and flows better while hot, and yet is equally durable when cold. This quality of flowing freely is of the very first importance in casting large plates, which, to be perfect, require to be without streak or bubble. Lime acts in promoting the fusibility of the silex and alkali; fulfilling, thus, the same office as is performed by litharge in the manufacture of flint glass. Manganese would have the effect of giving a slight tinge of red; but when mixed in the proper proportion with the blue of cobalt, and both together are

met by the natural slight yellow of the other materials, each neutralizes the other, so that scarcely any definite tint remains.

In addition to these ingredients, a considerable quantity of fragments of glass, or, as it is called, cullet, is used in combination with the fresh materials. Of these fragments there is always an abundant supply in the glass-house, produced from what is spilt in casting, and from the ends and edges that are cut off in shaping the plates. This broken glass is previously made friable by throwing it, while hot, into cold water.

Great care is required in mixing the materials. The sand, lime, soda and manganese, properly intermingled, are fritted in small furnaces wherein the temperature is gradually raised to a full red, or even to a white heat, at which point it is maintained, and the materials are carefully stirred until vapor is no longer given off, and no further change is undergone by the materials. This process of fritting occupies about six hours, and when it is nearly completed, the remaining portions of the ingredients, consisting of the cobalt and broken glass, are added.

There are two kinds of crucibles used: the larger ones, wherein the glass is melted, are called pots; the others, which are smaller, are called cuvettes. These last are kept empty in the furnace, exposed to the full degree of its heat, that when the glass is ready for casting and is transferred to them, they may not be injuriously low in temperature. When the glass is thoroughly refined it is dipped from the crucible with a copper ladle ten or twelve inches in diameter, and transferred to the cuvette, where it is suffered to remain some hours in the furnace, that the air-bubbles formed by this disturbance may have time to rise and disperse.

Another essential part of the apparatus consists in flat tables whereon the plates of glass are cast. Formerly these were made of copper, but iron is found to answer as well; and at Ravenhead, England, there is a table of this description that weighs fourteen tons, placed in a glass-house three hundred and thirty-nine feet long, one hundred and fifty-five feet broad, and proportionally high.

When the melted glass in the cuvette is found to be in the

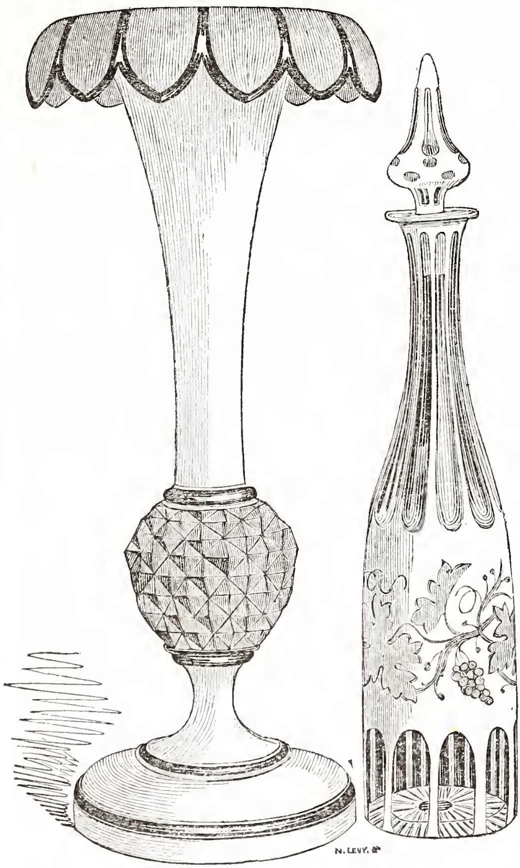
exact state that experience has pointed out as most favorable for its flowing readily and equally, this vessel is withdrawn from the furnace by means of a crane and placed upon a low carriage, in order to its removal to the casting-table, which is placed contiguous to the annealing oven. The cuvette is then wound up to a certain height by a crane, and by means of another simple piece of mechanism, it is swung over the upper end of the casting-table and thrown into an inclined position, when a torrent of melted glass is poured over the surface of the table, which must previously have been heated and wiped perfectly clean.

The glass is prevented from running off the sides of the table by ribs of metal, one of which is placed along the whole length of each side, the depth being the exact measurement which it is desired to give to the thickness of the glass. A similar rib, attached to a cross piece, is temporarily held, during the casting, at the lower end of the table. When the whole contents of the crucible have been delivered, a large hollow copper cylinder, made perfectly smooth, and which extends entirely across the table, resting on the side ribs, is set in motion, and the glass during its progress is spread out into a sheet of uniform breadth and thickness.

When the plate of glass thus formed has sufficiently cooled it is slipped from the table gradually and carefully into one of the annealing ovens, where it remains in a horizontal position during a period of about fifteen days; then it is withdrawn and undergoes the operation of squaring, grinding, polishing, and silvering, in order to fit it for sale. The squaring is done with a rough diamond, guided by a rule. The diamond cuts into the surface a certain distance, and by striking underneath the glass with a small hammer the piece comes away. The grinding is effected by embedding one plate in a wooden frame and rubbing another plate steadily and evenly over it, first sprinkling ground flint between the two. When one side of each plate has been sufficiently ground, the two are reversed and the process continued on the other side. The glass ground off in this way is usually one-half the weight of the plates, which are further polished with fine emery. Then the plates are cut up in such a manner that

any blemishes that may appear are brought on the edge of the plates or cut out without much waste. The finishing process is effected by means of brown oxide of iron rubbed on with a woollen cloth.

A new and beautiful invention for polishing large plate glass has been brought out in this country. The mechanical process by which this labor, heretofore so difficult, delicate and tedious, is performed, is exceedingly simple and ingenious. The plate glass, rough from the factory, is adjusted in a frame having an axle running through the centre of it into an iron support above. The surface rests on the outer part of a huge iron disc, which is made to revolve horizontally with great rapidity, and communicates a separate rotary motion to the plate. The principle on which



this motion is obtained is obvious enough, but its application is entirely new. No contrivance could more effectually overcome the great difficulty inherent in polishing a surface, viz. that

of distributing the operation with perfect equality over every part of it. The plate is kept on this disc until it is ground comparatively smooth by the attrition of coarse sand—a process requiring about two hours. It is then adjusted in a similar manner on a second iron disc to receive the final polish: the glass at this stage of affairs being only translucent. This disc is covered with felt, and a very soft and fine sand is used in grinding. In this disc there are grooves, by which air is admitted between the two surfaces, so as to overcome a great part of the friction, and thus effect a large saving in the motive power. The plate is kept on the second disc for about three hours, and when taken off is as clear as crystal.

Mirrors are silvered with an amalgam of mercury and tin. A slab of marble somewhat larger than the size of the required plate, and fitted with a frame open at the top, is prepared. There is also a ledge three inches deep round three of its sides. The bottom of the frame is supplied with a channel, to collect the surplus mercury and convey it to a vessel placed underneath. The slab is fitted on a pivot, so that one end may be raised and the other depressed at pleasure. On its surface a paper is stretched. Over this a sheet of very thin tinfoil, a little larger than the plate to be silvered, is then laid smoothly, and as much mercury as will remain upon the flat surface is poured on. The end of the slab, which is unprovided with a ledge, is then covered with parchment, and the plate of glass is allowed carefully to slide into the frame, resting the while upon the parchment.

The art of properly effecting the deposit of the glass upon the foil, consists in holding it during its sliding, in such a position that it will dip into the mercury, carrying a portion of the metal before it, but without once touching the tin in its passage. By this means any dust or oxide which may rest upon the mercury will be removed, and no air bubbles will remain between the glass and the tin, while, if the tin were touched, however slightly, it would certainly be torn.

When the entire surface of the glass plate has been passed, it is allowed gently to drop on the tinfoil and to squeeze out the superfluous mercury from between, all of which is collected in

the channel prepared for that purpose. The plate is then covered with a thick flannel and loaded at regular intervals with considerable weights, and the end of the slab is a little raised, to assist the escape of the superabundant mercury. After remaining in this position the entire day, the plate is cautiously taken from the frame and left for several days, to allow the amalgam to harden. About a month is required to perfect large mirrors, and from eighteen to twenty days for those of a moderate size.

A new mode of silvering and ornamenting glass has a fine effect. It is a novel plan of engraving the under surface of mirrors, &c., with borders of flowers and other devices, prior to silvering. The whole is then silvered, and the pattern appears as if in relief on the surface of the glass, and executed in the most delicate silver. This invention may be employed in various ways, for decorating interior fittings, furniture, and articles of glass designed for the table.

Another process of silvering, also a new invention, is by means of a solution of silver poured in between two walls of glass, so that we have a mirrored surface produced within and without the goblet or vase. This enables the manufacturer to improve the appearance of his article. As the inner part of a goblet is made of brilliant yellow glass, the silver looks as if it were gilded, and we have the effect of a silver cup gilt within. A very ingenious optical deception adds much to the beauty of glass ware treated after this manner. Before the two parts are combined, which is a secondary process, one of them is engraved, upon what will be the enclosed or silvered side. Sometimes both parts are thus engraved, and when they are brought together and united, which is not so difficult a process as it would at first appear to be, and the interior is silvered, the engraved parts, reflecting the light from different angles to the eye, assume the appearance of embossed surfaces, the relief in many instances being very remarkable. The touch, however, proves that the exterior is perfectly plain.

The coloring matter used to color glass is much the same as that employed for painting on porcelain, and to metallic oxides the artist must look for his materials. But there is this difference in the application; in decorating porcelain the colors are applied

superficially, in the manner of pigments, while they enter more intimately into the composition of glass, being transfused through the whole mass, and equally incorporated with its entire substance.

Gold, in a state of great division, and oxidated, has long been celebrated as a means of imparting to glass a most exquisite purple color bordering on red, resembling the ruby and nearly equalling that gem in the richness of its hue. It is not by any means easy to prepare glass of this color with any certainty of success. The manner of preparing the purple of Cassius from gold has already been described. It is not essential that gold used for this preparation should be absolutely pure or unalloyed, since neither copper nor silver, when present in small quantities, appear to alter or diminish its coloring powers. To the precipitate of Cassius is added about one-sixth its weight of perfect white oxide of antimony, which imparts the yellowish tinge considered to be an important ingredient in fine, ruby-colored glass. And great care is also required in managing the heat in preparing this color, for too great a degree will injure, if it does not destroy it, while every kind of vapor should be carefully excluded. One part of this color added to one thousand parts of glass, it is said, will impart to the whole a full, rich body of color.

Silver, in all its forms of oxidation, imparts a very pure and beautiful yellow color to vitreous bodies; but this color is easily destroyed through the accidental employment of too high a degree of heat—an evil, against the occurrence of which it is so exceedingly difficult to provide, that silver is very seldom resorted to as a coloring material by glass-workers. A good yellow color is obtained from the pure oxide of lead, when employed alone; but a sufficient quantity to give the required depth of shade would render the glass inconveniently soft. Chromate of lead, which is not liable to the objection, has therefore the preference.

Colors, varying in shade from brown to a very fine transparent yellow, may be given to common glass, by simply adding to it, while in a state of perfect fusion, some vegetable carbonaceous matter. The substance which has been most commonly employed for this purpose, is tartar, but almost any solid and inflammable vegetable matter will probably answer equally well.

The oxides of iron give many and very different shades of enamel colors. It has already been mentioned that the green color of common bottle glass is owing to the presence of iron in the unpurified sea-sand and ashes of which it is composed. An increased quantity of this oxide, if applied to glass when in a state of perfect vitrification, will give a yellow color to the mass. A still larger quantity will impart a brownish black hue, which, however, appears to be nothing more than a yellow very highly concentrated. The red color, which is imparted by the oxides of iron to porcelain, is owing to the state of imperfect vitrifaction, whereby the metal is held in a state of minute division throughout the mass, which same effect is apparent in glass up to a certain point; but when in the advanced stages of vitrifaction the heat is raised so that a perfect fusion of the glassy substance, as well as of the oxide, is produced, the color is immediately converted to yellow.

The black oxide of manganese is used to correct the impurities of the alkali employed in the original composition of glass, as well as to remove the green tinge resulting from the presence of iron. When these imperfections do not exist in the original ingredients, if manganese be added to the glass it will impart a purplish red color. This oxide also forms a principal constituent in the production of black glasses, but if any portion of arsenical salts should be present in the glass, the efficacy of manganese will be destroyed.

Copper, either in the form of simple or carbonated oxides, yields a very fine green, and the channels of success in the attainment of this are greater than attend the production of most other colors. It may also be made to yield a carmine red, and, if mixed with iron, a full deep red color, by adding to the glass with which it has already been combined a quantity of tartar. The iron must be in proportion of three to one. Copper, in the state of oxidation, is often used in combination with the oxide of manganese and iron, for the production of black glass. A green may also be produced from the protoxide of chromium. Chrome is the natural coloring matter of the precious metals, and is found to be a very valuable substance in the coloring of artificial gems.

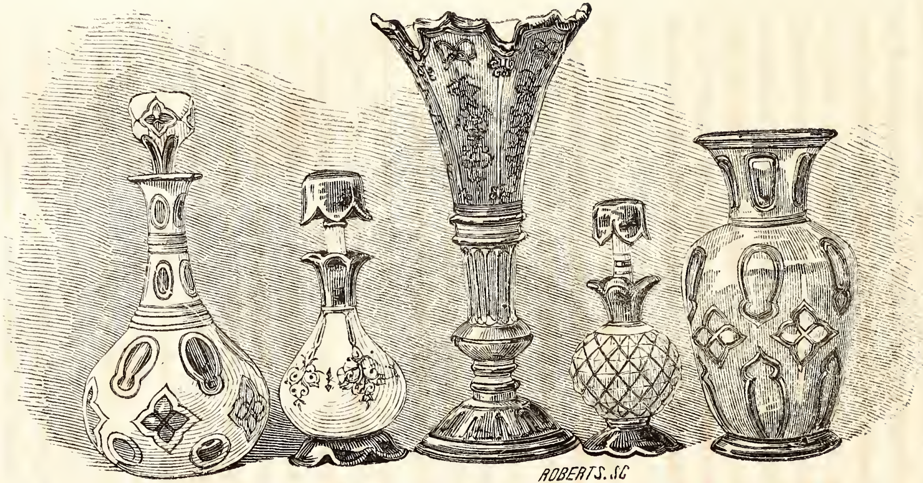
Oxide of cobalt is universally employed for the production of blue colors in vitrified bodies. It is also employed in the composition of other colors; combined with the oxides of lead and antimony, it furnishes green, and, if mixed with those of manganese and iron, it produces a very fine black. Greens of various tints, passing into turquoise, are often obtained by exposing for several days thin plates of brass upon tiles in the leer, or annealing arch of the glass-house, till it be oxidized into a black powder, aggregated in lumps. This, when pulverized and sifted, is again to be well calcined for several days more, till no particle remains in the metallic state, when it will form a fine powder of a russet-brown color. A third calcination must now be given, with a carefully regulated heat, its quality being tested from time to time by fusion with some glass, and when found to make the glass swell and intumesce it is of the right quality.

The basis of artificial gems is one of the colorless glass or pastes, or some other very similar vitrified compound, and this is colored with the oxides already referred to. Purple of Cassius and oxide of manganese give the proper hue for a garnet; oxide of copper and iron are required for the emerald; cobalt and manganese for a sapphire, &c.

Colored glass came into use in the time of Augustus, when the Romans employed it in the composition of mosaic decorations. Samples of colored glass have been taken from the coffins of Egyptian mummies, and the most ancient authors mention this material for the formation of artificial gems.

The earliest specimens of painted windows differ from those of more recent date, in having been formed of small pieces of glass, colored throughout, during the process of the original manufacture, and which is known as "pot metal." Pieces of this, cut to the shapes required, were joined together in the manner of mosaics by the interposition of lead, in a way which has since fallen greatly in disuse, the method of staining and burning in metallic colors in the surface of the glass having been found far more beautiful, and it admits of a greater variety of tints.

Colored glass blown into sheets is of course colored throughout, and this is called "pot metal." But another process is for



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the workman to dip his blow-pipe first into colored and afterwards into white glass; then he blows out the compound mass and a sheet is formed of two layers, one colored and generally very thin, and one white. This is called "flasbed" glass, and the only way to distinguish it from pot metal is to examine the edge. All the colors are occasionally made in this way; but ruby glass is always flashed, because it is of too deep a color to allow of being blown of the ordinary thickness. The layer of colored glass is seldom thicker than ordinary letter paper, the substance of the pane being white glass. These thin-colored strata are easily removed from the surface by the well-known method of glass-cutting and engraving, or by the action of the fluoric acid in etching or embossing.

There is another way of coloring glass, which is called staining, by which the various tints of yellow, from a faint lemon to a somewhat brownish red, may be obtained, but there is as yet no process for staining glass blue, green, &c. The staining is done after the glass is blown, and the process depends upon a peculiar property of silver, which is generally employed in the form of a chloride, (*luna* cornea or silver horn,) and is mixed and ground with some inert substance, as oxide of iron or pipe clay. The mixture or stain is floated over the article to be colored, by the aid of water or spirits of turpentine, and when dry the coating is about as thick as Bristol board. The glass is then brought to a red heat, and afterwards annealed; during the operation the silver penetrates and actually dies or stains the glass, while the oxide of iron or clay remains loose on the surface. The color thus obtained is perfectly clear and brilliant, and the surface of the glass appears to have undergone no change. The tint of the stain is intense, generally in proportion to the quantity of silver employed and the duration of the heat; but the darkest and richest tints can only be produced on glass made for the purpose. The best crown glass is generally chosen for staining or painting.

Glass is also colored yellow by antimony, or the admixture of what is known as the glass of antimony, which is obtained by roasting sulphuret of antimony to a state of antimonious acid, and then melting it with an additional quantity of the undecom-

posed sulphuret. The result of this is the formation of a glass of a transparent hyacinthine color. The Bohemians add a little oxide of iron to the glass of antimony, by which a greater depth of color is produced.

Staining and painting glass differ in some respects from all other styles of pictorial embellishments. They agree, however, generally with the processes used in painting porcelain, not only in the nature of the substance to be embellished, and in the materials whence the colors are derived, but likewise, for the most part, in the methods used for the application of those colors, and in the necessity which exists for fixing them by exposure to a degree of heat. The art is, indeed, in most particulars, analogous to the methods employed for painting porcelain, and which have already been treated of. The colors are drawn from the same class of mineral substances as afford enamel colors; they are prepared, and for the most part are applied, in the same manner, while any difference which may be found to exist in the mode of fixing and bringing out the effects of colors by the aid of fire, are more referred to the varied forms of the articles than to any actual difference observable between the habitudes of glass and porcelain.

Various compounds are recommended to be used with the colors as fluxes, in order to promote their fusion when exposed to the heat of the furnace; these are termed hard and soft fluxes, in proportion as they require a greater or less amount of heat for their perfect fusion. A fluxing compound very generally used, is made from flint glass, pearlash and borax, and the directions for fluxes for porcelain are equally applicable for those that are to be used for glass.

When enamel colors are applied to glass, they are, besides the union with a fluxing material, mixed in the same manner as for painting on porcelain, with some substance as a vehicle for causing them to flow readily from the brush, and at the same time to prevent the colors from blending themselves one with the other during the operation. Oil of lavender, balsam of capivi, oil of turpentine, and sometimes gum-water, are employed as a vehicle.

Many subjects may be painted on glass by persons who have

not acquired any previous knowledge of the art of design. The transparent portion of the material enables the artist to see both the outline and the shading of any pattern which may be fixed upon its under side. The outlines of every such pattern should be decidedly given, and the whole contour and shading must at once be obvious when looking on its upper surface. When the pattern paper is laid horizontally upon the glass, it must be secured by wafers at each of its four corners, to prevent its drifting. The glass must then be placed upon an easel, and the artist works exactly as he would were he engaged in painting on canvas, applying his colors with a soft brush, and resting his hands on a maul stick, in the same way, to avoid touching the surface of the glass with his hand.

The shading and coloring are very frequently performed on opposite sides of the glass, and this condition is almost invariably observed where the color to be applied can be made to flow with sufficient freedom; or, to use the words of the artist, which can be floated on the surface of the glass. In cases, too, where it is desired to produce tints, such as many shades of green, which would result from the admixture of two different colors, the same effect is produced by applying one of these to the face and the other to the reverse of the glass. There are only three colors which can be floated on, and which are called "stains," to distinguish them from all others, which must be laid on by the strokes of a brush, and these are orange, red, and lemon color.

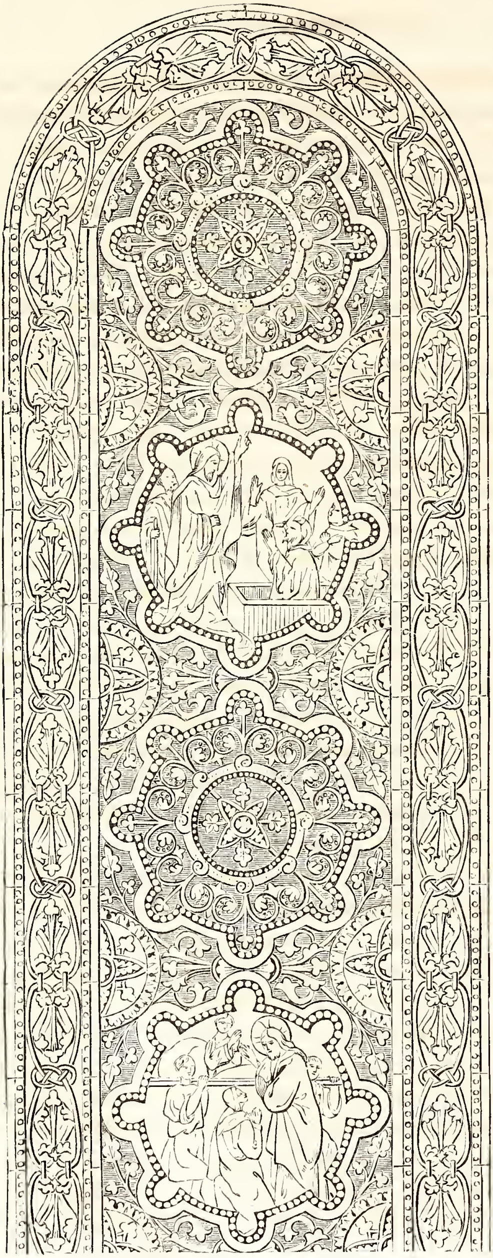
In floating on a stain, a large camel-hair pencil in a swan's quill, or a flat varnish brush of the same material, must be used. And in applying the stain it must be so managed that as it quits the brush it may float gently and evenly over the surface. Twelve hours are then allowed for it to dry, after which it is submitted to the action of heat in the kiln.

The size of the kiln will depend upon the number and magnitude of the pieces of glass upon which it may be desired to operate at one time. At Sèvres, single sheets of glass, half an inch thick, five and a half feet high, and five feet wide, have been fired. The glass is placed, during the firing, in a close iron box or oven, which is called a muffle, and which is provided with horizontal

iron shelves, placed at regular distances apart, whereupon the plates are deposited. The relative sizes of the muffles and furnaces are such, that a space of not less that four inches remains between the two on every side; by which means the fire may be made to envelope the muffle. This receptacle is provided with a tube, proceeding from its front, and narrow towards its extremity, the use of which is to examine the state of the glass from time to time, during the firing. The iron plates for supporting and separating the glass, and which are fitted to the shape of the muffle, are kept at their proper distance, usually about an inch asunder, by legs of the requisite length, placed at the four corners. If the plates of glass were placed in immediate contact with the iron shelves within the muffle, the metal would have an injurious effect upon some colors. The iron is also liable to warp, and would communicate its own distorted shape to the glass, when the latter was brought in contact with it in a softened state. This is provided against by making a bed for the glass of whiting, spread on the shelf to the depth of three-eighths of an inch.

The proper management of the fire in respect to the degree of heat employed, is a thing which must be acquired through practice. It may, however, be stated generally, that caution is necessary in the first stage of heating, so as to avoid a very sudden accession of heat; but when, on inspection, the glass placed in the muffle is seen to have acquired a dull red heat, the fire may be urged with safety, till the whole contents of the muffle have acquired a uniform white heat. When this effect has once been produced, no more firing is requisite; the fuel which is in the furnace must be allowed to burn itself out, and the kiln, remaining closed, must be left to cool gradually during ten or twelve hours, before it is attempted to remove the glass; at the end of this time it may be considered properly annealed.

When, on the establishment of Christianity, the ancient basilica were converted into Christian temples, the windows of these new temples were adorned with colored glass; but in these brilliant glasses of various colors, there were yet no figures, no ornaments painted upon the glass; they were composed of a number of pieces, variously colored, each being throughout of a uniform



STAINED WINDOW OF THE THIRTEENTH CENTURY. 58

tinge, and cut out into different patterns and arranged to form designs. These can only be considered as transparent mosaics.

The painted windows of the thirteenth, as well as those of the twelfth century, have nearly the same character. The general design consisted of little historical medallions of various forms, symmetrically distributed over mosaic grounds comprised of colored glass, borrowed from preceding centuries. This ground is arranged in square or lozenge-shaped panels, filled with quatrefoils, trefoils, and other ornaments: the whole design is surrounded with borders of varied patterns, of scroll-like foliage, interlacings, palms, and other leaves of different kinds. The subjects of the medallions are taken from the Old or the New Testament, or more often from the legendary history of the saints. The principal outlines of the designs, both of the medallions, and of the grounds, are formed by the lines of lead used for holding the different pieces of glass together, and which thus formed a black boundary to each subject. The pieces of glass are in general colored, rarely plain. Upon these pieces, which are always of small size, the folds of the draperies, and the details of the ornaments are portrayed by a reddish or bistre color, laid on with a brush. The shading is produced by a number of equal and parallel lines, such as are used in engraving and drawing. The flesh tints themselves are not expressed by any application of color; but a glass lightly tinged with violet forms the ground, and the features are indicated with this same bistre enamel.

The chief merit of the windows of the twelfth century, and of the thirteenth, and which, notwithstanding their many imperfections, causes them to be esteemed, is their perfect harmony with the general effect of the edifices to which they belong. At whatever distance we examine them, we are struck by the elegance of their form and the brilliancy of their color. The artist has had no intention of executing an independent work; he has given himself little trouble about a faithful copy of nature; his whole aim has been to contribute, under the direction of the architect, to the ornamentation of the building; and he has never failed of success through the skilful arrangement and the harmonious distribution of his colors, which, notwithstanding their brilliancy,

shed over the interior of the temple a mysterious light, adding much to the solemn grandeur of the architecture. This harmony of effect did not exclude a richness of detail. The mosaics of the ground and the borders which surrounded them are always of graceful patterns, of infinite variety and of charming originality. The subjects are characterized by a touching simplicity, neither devoid of life nor movement.

On a wooden table, which had previously been whitened with pulverized chalk, and sprinkled with water, the artist first marked with a rule and compass the exact size of the window or pane of the window to be composed. This done, he sketched out with lead or tin, and afterwards with a red or black color, the subject to be represented upon the glass, together with the borders and other ornaments with which it was to be decorated. He then noted down the color of each part of the composition, either by color applied upon the table in the different compartments which formed the design, or by a conventional letter, which referred to a given color. The artist, from these memoranda, then took as many pieces of colored glass as there were different compartments in the design, and placing these pieces of glass, one after the other, on the spaces they were to fill, he traced upon them, with chalk ground in water, the outlines of the design he saw, through the glass, upon the table.

The glass-makers were not then acquainted with the method of cutting glass with the diamond, which did not begin to be used until the sixteenth century. To cut out all these pieces of glass, they made use of a rod called the dividing iron; this was heated in the fire and drawn along the lines to be divided, which they took the precaution of slightly moistening, if the glass was hard and did not easily break. After the portions were cut out, the remaining asperities were removed by filing them with a kind of iron tool or claw, and the parts made to fit together accurately.

All the pieces of glass thus cut out were then carried back to the table upon which the design was drawn, and each laid over the place it was to occupy. When the enamel painting thus applied upon the tinted glass was dry, the pieces of glass were car-

STAINED WINDOW OF THE FIFTEENTH CENTURY.

ried to the furnace to be burned. The burning finished and the glass cooled, the different pieces composing the design were again put together and fastened by strips of lead.

In the fourteenth century, the painter upon glass endeavored to copy nature with fidelity, and sometimes he was successful. He began to seek the effects of chiaroscuro, to introduce lights and shadows into the ornaments and draperies. The flesh tints are no longer expressed by violet-tinted glasses, but painted upon white glass, in a reddish-gray color, and their models approach more nearly to nature. The pieces of glass are longer, the strips of lead are placed at wider intervals, large single figures become more common, occupying an entire window, and at the end of the century we find them of large dimensions. These figures are placed under elaborate canopies, and no longer on a mosaic ground, but one of plain blue or red.

The consequence of this progress in the art of design is seen in the efforts of the glass painter to create an individual work, yet without an absolute neglect of the general effect to be produced. If he did not yet venture upon a design with large figures, subject to the rules of perspective, he gave up the small medallions filled with legendary subjects.

In the middle of the fifteenth century, the revolution in the art of painting upon glass was complete. The palette of the painters had been greatly enlarged by means of chemistry, and the quantity of enamel color at their disposal enabled them to give up entirely glass colored in the mass, and to paint upon a single piece of white glass with enamelled colors laid upon its surface. Thenceforth glass was nothing more than the material subservient to the painter, as canvas or wood in oil painting. Glass painters went so far as to copy upon white glass as upon canvas, the masterpieces of Raphael, Michael Angelo, or the other great painters of the Italian Renaissance. They executed small pictures most highly finished, and attained to great richness of coloring, through their skilfulness in coating the enamel colors upon each other. And the successive artists carefully preserved, until the beginning of the eighteenth century, the style of the

large church windows of the fifteenth, by uniting with the brilliant coloring of the glass, tinted in the mass, and the coated glasses before mentioned, all the finish that can be obtained on the flesh tints and small subjects, by the application of vitrifiable colors upon the surface of colorless glass.

AMERICAN CUT AND PRESSED GLASS.

face c. xviii, p. 285.

CHAPTER XVIII.

GLASS.

THE art of cutting glass is supposed to date from about 1609, at which time Caspar Lehmann, then in the employ of the Emperor Rodolphus II. as a cutter of iron and steel, obtained from the emperor the exclusive right to cut glass, and he also received the appointment of glass-cutter and lapidary to the court. Prior to that date, engraving on glass consisted of a few scratches made with a diamond, and for works of this description the Venetians of the sixteenth century enjoyed a high reputation throughout Europe. It was long after the period above named that the art assumed the important position it has since obtained. Nuremberg, the city of the arts, excelled in glass-cutting during the middle ages, and great taste and ingenuity are often displayed by the artists of the present day in the form and embellishment of the various articles of this description that come from their hands.

The implements employed by the glass-cutter, although, owing to the great variety of the work he has to execute, they are of necessity numerous, yet partake of the simplicity observable throughout the various processes of the manufacture. In every establishment a shaft causes the revolution of numerous large wheels or drums fixed thereto, and each of these, connected by a band with a pulley on the axle of a small wheel, occasions the latter to revolve with great celerity. These small wheels are the cutting instruments. They are all so arranged that any one can

be unfixed and another substituted in its place without difficulty. As regards their form, they are either narrow or broad, flat-edged, mitre-edged—that is, with two faces, forming a sharp angle at the point of meeting—convex and concave; and of these different wheels a great number are always to be found in the workshop of the glass-cutter.

The materials employed in the formation of these cutting-implements are, iron, both cast and wrought, stone, and willow wood. Wrought iron is only used for cutters, of the narrowest dimensions, and which it therefore would not be possible to make sufficiently tough of cast metal. Iron wheels are only used for the first or roughest part of the operation, and their employment is dispensed with altogether where it is intended that the pattern shall be at all minute, and the metal and the sand, which must be used in connection with it, would act too roughly, and frequently portions of the glass would be chipped away. For such minute work a fine-grained stone, moistened with water, must be used. The further smoothing and subsequent polishing of the cut surfaces are effected with wooden wheels; for the first of these objects the edge is dressed with either pumice-stone or rotten-stone, and for imparting the highest degree of polish that is required for properly finishing the process, putty powder is employed.

Beneath each one of the cutting wheels a small cistern is fixed to receive the sand, water, or powder, which has been used; and over the wheel a small keg or a conical vessel is placed, the cock or opening at the bottom of which is so situated and regulated that the requisite quantity of moisture will be imparted from it to the wheel. The vessel which is placed over the iron wheel is furnished with fine sand, and into this water is admitted in such quantities as will insure the constant delivery of the moistened sand upon the face of the wheel, in such proportions as the workman finds most desirable. The emery powder, rotten-stone, or putty powder, are applied from time to time, as required by the workman, on the edge of the smoothing or polishing wheel.

The grinder seats himself on a stool in front of his wheel, and taking in his hand the glass to be ornamented, applies this to the face of the cutter, calling into requisition the steadiness of his

hand and the correctness of his eye, in the successive applications to the wheel of those parts which are to be cut. Placed at his right hand, each workman has a small tub containing water, which he uses from time to time to wash away the particles of sand or powder which may adhere to the glass, that he may the better judge as to the progress of his work.

The grinding of glass, or frosting it, is usually applied to the inner surface of globes and shades of lamps, and to effect this the article is fixed in a lathe, and the workman, holding in his hand a piece of wood, which is covered with wet sand, causes this to rub with the necessary degree of force against the inner surface during the rapid revolution of the glass.

Ornamental figures placed on articles of glassware, are produced by compressing a portion of glass in a mould, and then they are attached to the article. These designs are usually raised, and they have an advantage over engraving by retaining a polish, but the edges are not as clear and sharp as when cut on the wheel; and there is another objection—figures on glass ought to be treated in intaglio, and not in relief.

Another method of engraving is to employ fluoric acid to bite away a portion of the surface of the glass, leaving the figure in intaglio or in relief. For the former the whole surface, with the exception of that taken up by the design, is covered with a varnish, either a solution of isinglass, or turpentine varnish mixed with a small proportion of white lead, and the acid is then applied to the exposed parts, which it gradually eats away till the required depth is obtained. If the figure is to be left in relief, then the design is traced with the varnish, and the rest of the vessel's surface is subjected to the action of the acid. By this means the figures are left in relief with their original polish.

In the six hundred and twenty-fifth part of an inch, the following words have been engraved upon glass: "Lowell & Senter, watchmakers, 60 Exchange street, Portland. Written by Fremont, at Paris, 1852." This is equal to forty-six thousand eight hundred and seventy-five letters in the circle of an inch in diameter. The most powerful magnifying glass reveals only a few apparent scratches, but with a microscope of great power the in-

scription can be plainly read. The body of an ordinary pin, placed between the inscription and the microscope, completely covered the inscription, the circle in which it is inscribed being smaller than the head of a common pin.

But even this has been surpassed, the Lord's Prayer having been executed within the same compass; and within the one hundredth part of a square inch, that is, the fiftieth of an inch in length, and the two hundredth of an inch in width, the following lines have been engraved:

> "A point within an epigram to find,
> In vain you often try;
> But here an epigram within a point
> You plainly may descry."

The process of engraving consists of a mechanism by which the point of the graver or style is guided by a system of levers, which are capable of imparting to it three motions in right lines, which are reciprocally perpendicular, two of them being parallel and the third at right angles to the surface on which the characters or designs are written or engraved.

Etching on crown glass is a very simple process. The glass is first heated in a sand bath, and then rubbed over with purified bees'-wax, the temperature of the glass being such as to cause the wax to melt completely and uniformly over its surface. When every part of the plate is covered with wax, it may be set aside to cool. A paper having the design boldly drawn upon it, may then be attached to the unwaxed side of the glass, and the workman traces the lines through the wax by a pointed instrument, care being had that the point clears all the wax from the glass wherever the design comes.

This done, some coarsely-powdered fluor-spar must then be placed in a vessel, together with a quantity of sulphuric acid, well mixed together, and as soon as they are incorporated, the glass should be placed over the vessel, the wax surface downward, when a moderate degree of heat must be applied to the bottom of the vessel. The fumes of fluoric acid soon arise and attack the surface of the unprotected portion of the glass. In

half an hour it may be removed, washed, and the wax scraped off, leaving the design perfectly etched upon the surface of the glass.

A process for printing designs on glass by electricity has been discovered by W. R. Grove, of London, inventor of the galvanic battery which bears his name, and he has given an account of it in the Philosophical Magazine. Two plates of window glass, about three inches square, were dipped in nitric acid, then washed, and dried with a clean silk handkerchief, and coated on the outside with pieces of tinfoil a little smaller than the glass. A piece of a printed handbill was laid between the plates thus prepared; the tinfoil coatings were connected with the secondary terminals of a Ruhmkorff's coil, and removed after a few minutes electrization. Now, the interior surface of the glass, when breathed on, showed with great beauty the printed words which had been opposite it, these appearing as though etched on the glass, or having a frosted appearance; even the fibres of the paper were beautifully brought out by the breath, but nothing beyond the margin of the tinfoil. These impressions were fixed by holding them over hydrofluoric acid—powdered fluor-spar and sulphuric acid slightly warmed in a leaden dish.

Mr. Grove cut out of thin white letter paper the word "Volta," and placed it between the plates of glass. They were submitted to electrization as before, and the interior surface of one of them, without the paper letters, was subsequently exposed in the hydrofluoric acid vapor; the previously invisible figures came out perfectly, and formed a perfect and accurate etching of the word Volta, as complete as if it had been done in the usual mode by an etching ground. This, of course, could be washed and rubbed to any extent without alteration. The results obtained give every promise for those who may pursue this as an art, of producing very beautiful effects, enabling even fine engravings to be copied on glass.

Venetian glass balls are made of a collection of waste pieces of filagree glass, conglomerated together without regular design. This is packed in a pocket of transparent glass, which is adhesively collapsed upon the interior mass by sucking up, producing

outward pressure of the atmosphere. The *mille fiore*, or star work, is more regular in design than the balls, but of the same character. It is formed by placing lozenges of glass cut from the ends of colored filagree canes, ranged in regular or irregular devices, and incased in flint transparent glass. A double transparent glass cane receives the lozenges between the two surfaces, the whole is reheated, a hollow disc, communicating with the blowing iron, adheres to the neck, ard the air is exhausted or sucked out of the double case, producing the desired effect.

The manufacture of glassware, with ornaments in filagree or in colored thread, is no longer a secret, and now that collectors have drawn attention to its merits, imitations have been attempted by many manufacturers, who, without having yet attained to the lightness and perfection of the forms of the sixteenth century, have still introduced into commerce glasses of some elegance.

The vases with colored threads and filagree ornamentations are composed of the assemblage of a certain number of small glass canes of cylindrical form, one-eighth to one-quarter of an inch in diameter, made either of opaque white glass, of colored glass, or of glass enclosing filagree patterns. These canes, prepared beforehand, are disposed in such order as the glass-maker may choose, and are often placed alternately with canes of plain white glass—that is, colorless and transparent glass; they are welded together by fusion and blowing, and finally moulded, when they form a compact homogeneous paste, convertible, like any piece of ordinary glass, into vases of every form. As many as twenty-five or thirty, or even forty canes may enter into the composition of a Venetian vase; and in order to make a cane of colored glass, the glass-blower takes, at the end of his blowing iron, the requisite quantity of glass from the pot in which it is fused, and rolls it upon the marver, in order to cause the substance to adhere to his blowing-iron, and to make it into a cylindrical mass of from two and a half to three inches long, which he allows partially to cool, to give it consistency. He then dips the end of the blowing-iron, charged with the little column of colored glass, into a melting pot containing ordinary white glass, in order to surround the colored glass with a coating of white.

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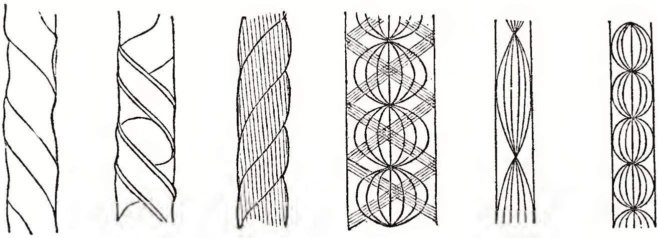
He draws the blowing-iron from the pot, and again "marvers" the lump to make the transparent glass of an even thickness round the colored, and to form of the whole a kind of truncated column of from two and three-quarters to three inches in diameter. This column is then exposed to a strong heat, to weld the layers together, and next drawn out so as to form a cane of from one-eighth to one-quarter of an inch in diameter, the centre of which is colored, surrounded by a very thin surface of white colorless glass. It is then divided or "whetted off" into pieces of different lengths. These little canes, thus prepared and modified, by the flattening that takes place in the making of the vases, form these simple threads, of various widths, with which a number of the Venetian vases are enriched; they are also the elements of the canes with such varied filagree patterns, of which filagree vases are composed.

The manufacture of canes enclosing filagree patterns is much more complicated, and varies according to each pattern. It will be sufficient to know, that by placing in a given order canes of colored glass, interspersed at greater or less distances, according to the pattern desired, with canes of plain white transparent glass, and by placing these canes so arranged, either in a pocket of soft white glass, or against the sides of a cylindrical mould, which is then filled with white melted glass, a thick column is formed, in which the rods of colored glass are distributed, either in the interior or on the surface of the white glass. This column, which is then taken to the fire, in order to obtain a complete adherence to all the parts of which it is composed, is afterwards drawn out to form a little cane of white glass of from one-eighth to one-quarter of an inch in diameter, in which the canes of colored glass are reduced to threads of extreme tenuity, which twist in varied patterns in the centre of the newly-obtained cane, or roll in spiral threads upon its surface, according to the previous arrangements and the various inflections which the workman may have given the material in the act of drawing it out. Canes of glass, with various filagree patterns, are here represented.

The glass-maker, having provided himself with the different canes of colored filagree, and plain white glass, may now proceed

to the fabrication of vases. He arranges around the inner surface of a cylindrical mould as many canes as he requires to form a complete circle around the sides of the mould. These canes are fixed to the bottom of the mould by means of a little soft earth which has been spread over it. The workman can choose his canes of various colors and patterns, forming so many different combinations of filagree; he can place them alternately, or can



intersperse them with canes of plain white glass. The canes, thus arranged, are heated in the glass furnace; the glass-maker then gathers, with the blowing-iron, a small quantity of white glass, to make a solid ball, with which he fills up the empty space formed by the circle of rods which cover the inner surface of the mould; he blows again, to make the rods adhere to the ball of plain glass, and takes it all out of the mould. The assistant workman instantaneously applies upon the colored or filagree canes, which are thus made to form the exterior surface of the cylindrical mass, a string of soft glass, in order to fix them more securely together. The piece being thus arranged at the end of the blowing-iron, the glass-blower carries it to the mouth of the furnace to soften it, to weld all its parts together, and to give it sufficient elasticity to yield to the action of the blowing-iron; he then rolls it on the marver, and when the different canes, united by blowing and manipulation, have reached such a point as to constitute a compact, homogeneous mass, he cuts with a kind of pincers, a little above the bottom, so as to unite the canes in one central point. The vitreous mass thus obtained is then treated by the glass-maker according to the ordinary processes, and he makes of it, according to his taste, an ewer, a cup, a vase, or a goblet,

in which each cane, either colored or with a filagree pattern, serves to form a stripe.

If no twisted movement has been given to the vitreous mass in the course of fabrication, the threads of colored glass on the filagree designs remain in a straight line, proceeding from the lower part of the vase to the upper, or else from the centre to the circumference. If the ball, on the contrary, has been slightly twisted, this twisting then imparts to the different colored threads of filagree patterns which have entered into the composition of the vase, that spiral direction so often met with in specimens of Venetian glass.

The Venetian glass-makers succeeded also in making vases composed of two cases of sheets of glass, with simple colored threads, which were twisted beforehand, and then placed over each other. This super-position, by which the threads of colored glass were crossed at right angles, produced a network of opaque threads, which, in consequence of their thickness, leave between each mesh of this kind of net a small bubble of air, enclosed between the two layers of white glass, which form the foundation of the vase. These pieces are, perhaps, the most remarkable performances of the glass-makers of Murano.

The Venetians also made vases with pieces of glass cut off the ends of the filagree canes, the section thus presenting variously colored stars, scrolls, and other geometrical forms. These slices or segments of canes, cut about half an inch in length, were scattered between two layers of white or tinted glass; the substance was then marbled and blown again, to form of the whole a new mosaic mass, ready to be shaped into vases of every description.

Glass beads were first manufactured at Murano, and there they are still made in great quantities for exportation, of every size and color. To effect this the glass is drawn out in the form of tubes, to the length of one hundred or two hundred feet, and these are broken into lengths of about two feet. Then, to give the beads their proper size, these strips are cut into pieces, each of which is in length equal to the diameter of the tube. This is done by the aid of a knife. Then these little fragments, with coal dust and powdered clay, are put into a revolving cylinder,

where they are subjected to heat and motion, and in this way all the rough and sharp edges are removed, and then they are passed through sieves, by which means they are sorted to the sizes.

The glass beads made in imitation of natural pearls for toilet ornaments, the invention of which dates from the year 1656, are very different from the above, both as regards their application, mode of production, and origin. These are small solid glass beads, of the same size as native pearls, which they are made to resemble by a coating of varnish, and which gives them a peculiar pearly lustre and color. A maker of rosaries, by the name of Jaquin, was the first to discover that the scales of a species of fish communicated a pearly hue to water. Based upon this observation, glass globules were first covered on the outside, but at a later period on the inside, with this aqueous essence. The costly essence, however, of which only a quarter of a pound could be obtained from four thousand fish, was subject to one great evil, that of decay. After trying alcohol without success, in consequence of its destroying the lustre of the substance, sal-ammoniac was at length found to be the best medium in which to apply the essence; a little isinglass was also mixed with it, which caused it to adhere better. The pearls are blown singly at the lamp; a drop of the essence is then blown into them through a thin tube, spread out by rolling, and the dried varnish is then covered in a similar manner with a layer of wax.

The scales of the roach and dace are chiefly employed for this purpose, and form a considerable source of profit to the fishermen of the Seine, in the environs of Corbeil, who bring them to Paris in large quantities during the season. They must be stripped from the fish while living, or the glistening hue which we admire so much in the genuine pearl cannot be imitated.

Glass tubes have this singular property. If a tube of this material be placed before the fire in a horizontal position, with its extremities supported, it will acquire a rotary motion around its axis, moving at the same time towards the fire, notwithstanding that the supports on which it rests may form an inclined plane the contrary way. If it be placed on a glass plane, such as a piece of window glass, it will move from the fire, although the

plane may incline in the opposite direction. If it be placed standing nearly upright, leaning to the right hand, it will move from east to west; if leaning to the left hand, it will move from west to east, and if it be placed perfectly upright it will not move at all. The causes of these phenomena have never been explained.

The elasticity of glass exceeds that of almost all other bodies. If two glass balls are made to strike each other at a given force, the recoil, by virtue of their elasticity, will be nearly equal to their original impetus. Connected with its brittleness are some very singular facts. Take a hollow sphere, with a hole, and stop the hole with the finger, so as to prevent the internal and external air from communicating, and the sphere will fly to pieces by the mere heat of the hand. Vessels made of glass that have been suddenly cooled, possess the curious property of being able to resist hard blows given to them from without, but will be instantly shivered by a small particle of flint dropped into their cavities. This property seems to depend upon the comparative thickness of the bottom; the thicker the bottom is, the more certain of breakage by this experiment. Some of these vessels, it is stated, have resisted the stroke of a mallet, given with sufficient force to drive a nail into wood; and heavy bodies, such as musket balls, pieces of iron, bits of wood, jasper, stone, &c., have been cast into them from a height of two or three feet without any effect; yet a fragment of flint not larger than a pea, dropped from three inches' height, has made them fly.

Holland is supplied with gas through six-inch tubes of glass, which, though laid beneath the streets several years since, have not only stood the ordinary traffic, but have borne without fracture the passage of heavy artillery, dragged over them, to place the question of their strength beyond a doubt.

There are several accounts on record of glass having been made malleable, but they all lack confirmation, and no approach has ever been made to it in modern times. A preparation, called "soluble glass," has, however, been made. For this purpose, quartz is ground to an impalpable powder, washed and allowed to settle, when it is again ground. Of this powder take fifteen

parts, ten parts of potash, and one part of charcoal, and melt them together. The mass, having been purified by washing it in cold water, is boiled with five parts of water, in which it slowly but entirely dissolves. This solution gelatinizes on cooling, and dries up when exposed to the air, without absorbing carbonic acid gas, into a transparent colorless glass. One part of quartz and two of soda, for some purposes, appear to form a more perfect soluble glass.

The chief use of this silicate is to coat wood, paper, &c., by which these and similar bodies are rendered much less combustible. And when mixed with some other substance, it forms an efficient cement. If a piece of wood be covered with the silicate of potash, or, still better, with a silicate made into a paste with plaster-of-Paris, chalk, or clay, it will be found, if thrown into the fire, that it will only undergo combustion when the heat is sufficiently strong to char it through the vitreous coating, and then it will only be converted into charcoal, as it would be in a metal vessel.

A petition was recently presented in the House of Lords, from a gentleman of the name of Daines, asking Parliament to inquire into the merits of an invention he had perfected and patented for preventing from decay the exterior of stone work, and rendering buildings impervious to the effects of time and atmospherical influences; and, if satisfied with the result of such an inquiry, to adopt the invention for national purposes. Lord Lyndhurst, who presented the petition, stated that he had received a certificate, of a highly satisfactory nature, from Sir Charles Barry, which stated that the invention has been applied to one thousand four hundred square yards of the exterior stone work of the new House of Parliament, and, after the test of two years, exhibited the most satisfactory and successful results.

This preparation is obtained by dissolving broken flints in a solution of caustic alkali, at a temperature of three hundred degrees Fahrenheit. A properly prepared sand is mixed into a pasty mass with this solution, and while in a plastic state it is pressed into moulds of any form. In the course of a short time the mass hardens; it is then exposed to the action of heat to

BOHEMIAN GLASS

drive off the water, and the whole is converted into a very coherent sandstone.

By this means any kind of stone can be imitated, care being taken in selecting and preparing the mass which is to be cemented together. The facilities which this preparation offers for excellence in ornamental work, at a moderate cost, are very great. Figures, foliage, and, indeed, any architectural decoration, can be produced most readily, and at a considerable saving, the labor of cutting being entirely dispensed with.

It is a curious point, in connection with the cementing powers of this dissolved silica, that it loses its solubility during the operation. This is a very important property, since it insures the stone against the influence of rain or any atmospheric influences.

As a preventive of destruction, the surface of the stone is coated or saturated with the soluble mass. The mode of application is, to brush over the exterior of the building with the solution, and many advantages are gained by repeating it several times. If the experiment be tried on a portion of a piece of Caen stone, it will be found that the unsilicated portion will wash up when brushed with water, that it will be attached by either sulphuric or muriatic acid, even when much diluted, but that no such action will take place over the silicated portion.

This soluble silica may be mixed with whitewash and applied to walls, or even common chalk may be mixed with it, and at once used as whitewash; it will then resist sponging with water, and if applied to walls already whitewashed, it renders them very adhesive and capable of resisting moisture.

The success of the coloring in Bohemian glass depends upon a complete vitrifaction of the pigment without any irregular extension of the color over the matrix. The materials of which the glass is made, as far as they can be ascertained, and they seem to make no secret of it, appear to be the same as those in use in England. The gold used in ornamenting the glass is from the purest ducats, dissolved in strong acid, and the oil with which the colors are mixed is of turpentine. All the finishing goes on in the little cottages by which the furnace is surrounded, and with which the valleys and the sides of the hills are studded. In

these the exquisite scrolls and flowers which we admire in the best specimens of Bohemian glass are produced by men bearing all the appearance of simple cotters. They are seldom provided with more than two very ordinary brushes, a small one and another of a larger size, and they frequently work without any pattern or indicating lines upon the glass they are painting; but, perfect from habitude, the scrolls and wreaths, and flowers, come out with the same facility as one traces a name on the dewy pane of a window. Often the whole family are brought up from childhood in painting and in drawing on glass, thus producing a race of hereditary artists.

Each cottage, where the painting and gilding go on, is provided with a small oven, into which the glass is put to bake in the colors, where it is kept for a day and allowed to cool down. The white figures and flowers, when they go into the oven, are of a dark chrome color, but come out pure white, as will be observed on examining any glass on which flowers of this color are painted. The gold also, when laid on, is of a dead brown, and when burnt in, is polished, generally by women of the family. The gold in many instances is left unpolished, and only the stalks and fibres are burnished, which gives an excellent effect. Then, again, the effect is produced, as in the specimens here presented, by engraving on a glass of two colors. For this purpose the brilliant ruby glass, over a white body, is frequently selected, and the figures brought out by skilful hands are often of exquisite beauty.

Fruit knives of Bohemian glass are now made in Paris. The blade is of a white crystal, and the handle is a happy mixture of white and blue, or white and claret colors. Hitherto silver knives have been thought indispensable for fruit, but this crystal novelty is likely to supersede them. They are not only ornamental for the dinner-table, but are more easily kept clear and bright than silver.

The product of the little kingdom of Belgium, the greatest glass-producing country in the world, is fifty million feet of sheet glass annually: equal to twenty-two thousand three hundred tons,

or twenty-five per cent. more than is made in England of both crown and sheet glass.

It was about the year 1790 that the first attempt to establish a glass manufactory on this continent was made. It was unsuccessful; but about the year 1800 another effort was made, and in Boston the manufacture was established. From this Mr. Jervis dates the founding of all the crown and cylinder, window and flint glass works in the Atlantic States. Other companies, for the manufacture of glass, were from time to time formed, and in 1817 the New England Glass Company was established. The Brooklyn Manufactory was established soon after this, and the founder, Mr. Gillerland, has had the reputation of being the best metal mixer in the country. In 1825 the Sandwich Flint Glass Manufactory was established. The weekly melt at that time did not exceed seven thousand pounds, and the yearly products were valued at seventy-five thousand dollars, giving employment to fifty or sixty hands; now it employs rising four hundred hands, and its yearly products are valued at half a million of dollars. In 1851 this company commenced the manufacture of glass bowls by machinery, of a magnitude far exceeding in size and weight any heretofore made by glass manufacturers in this country. The bowls weigh about sixty pounds, are twenty-one inches high, and twenty-two inches in diameter at the top. They received the name of the "Union Bowl," and being made of pressed glass, were offered at a cheap rate.

In this country many improvements have been made in the manufacture of glass, and one of these, resulting from observation

and experience (which led to the discovery that large masses could be melted at less cost than the same quantity divided into smaller parts and fused separately), is an improved form of furnace, which effects a great saving of fuel. And large sums have been expended for the introduction of machinery for facilitating the various operations through which the crude metal must pass. Mould machines, for the purpose of pressing glass into any form, have revolutionized the whole system of flint glass manufacture, and the articles now turned out by this machinery so closely resemble cut glass, that the practised eye can only detect the difference, and the tendency has been so to reduce the cost of glass that its consumption has increased tenfold. The materials are all of native production. The pig lead is obtained from the Western mines, ashes from various sources in different states, and silex is also indigenous. The materials consumed yearly in the manufacture of flint glass are something near the following estimate: Coal for fuel, forty-eight thousand tons; silex, six thousand five hundred tons; ashes, nitre, &c., twenty-five hundred tons, and lead thirty-eight hundred tons.

The American Plate Glass Company, Williamsburg, is engaged in making plate glass, particularly rough plates, for floors, &c. They have a table for castings that weighs thirty-two tons. The fires are kept up by Cumberland coal, and are not allowed to go out till the furnaces are destroyed, which generally occurs after a year's use. The pots, after a casting, are usually returned to the furnace to be refilled, and they last about a month. The temperature of the establishment is above that of ordinary thermometers. The furnace fires are watched, as a solar eclipse, through a dark-colored glass, the intensity of the light being unendurable by the naked eye. The appearance of the sea of glass when poured upon the table, is exceedingly beautiful. At first it is of a bright whiteness, dazzling to the eye; it then rapidly changes to pink, scarlet, crimson, and a dark, murky red, streaked with black, in which state it is thrust into the kiln. Fifty seconds from the time the mass is poured out, it is sufficiently solidified to permit it to be pushed rapidly upon a table having a wooden surface, resting upon rollers, which is at once carried for-

GLASS. p. 301.

ward in this way, blazing and smoking, to the mouth of the kiln, in which it must remain from three to five days, when it emerges annealed and ready to be trimmed.

The British claim superiority in the pure crystal of their fabrications; the Bohemians excel in coloring it, and the French in the novelty of their combinations and appliances. But it is no less certain that American glass is of remarkable purity; and one of the British Commissioners to the United States declared, that if the New England Glass Company and the Sandwich Company had sent specimens of their pressed glass to the French Exposition, they would have done themselves no little credit.

CHAPTER XIX.

ORNAMENT.

IF the most effectual way to raise the Arts and Sciences to the highest standard of excellence is, to multiply the number of those who can observe and judge for themselves, then the present generation owes a debt it will hardly be able to pay in the limited time allotted to man to work. Generations before us may have been equally remiss, but with the present we have only to do. The settlement of a new country, the excitement attendant on the formation of new states and organizing a republic, have no doubt served in a great measure to withdraw the attention from objects calculated to refine and polish a nation, to the rougher work of erecting log cabins, digging canals, and opening roads. But time has insured to us all that we could desire in this respect. The resources of the country have been developed beyond the expectations of the most sanguine, and now the tendency is to a refined and luxurious style of living, for which we have not prepared by a suitable course of training. Artists may produce excellent designs, but they will avail little, unless the taste of the public is sufficiently cultivated to appreciate them, and to so desirable an end we cannot attain without some knowledge of the different schools of art, and familiarity with the principles which govern the work of the best designers.

Our styles of ornamental art are all directly traceable to the

Egyptian, Greek, and Roman originals, the principles of which, though modified and adapted to our wants, are the same as when first inculcated ages ago. The Egyptian style was an arbitrary one, and was governed by the laws of the land, which allowed but little scope to the imagination. The artist expressed his meaning by the most conventional treatment of natural objects; and without resorting to other means they have recorded the history and acts of their kings in imperishable characters. The use of these hieroglyphics has passed away, and all that we retain of Egyptian origin, is the zig-zag, the lotus, the palm, the star, the fret, and one or two similar and equally symmetrical arrangements of objects, valued for their beauty and ready adaptation to various ornamental purposes. The lotus of the Egyptians, and the Greek acanthus, are the two roots of our leaf ornaments. The winged globe, too, may be numbered with the Egyptian ornaments that are still retained, and the beetle, though seldom employed, is also from the same source. The art of the Egyptians was grand, simple, and imposing, and where a gorgeous effect was desired, it was secured by a free use of gold, precious stones, and ivory, all of which were within their reach.

The art of the Grecians was highly ornamental, and that of the Egyptians was expanded under their influence: thus, the column of the Egyptians was made to represent a bundle of reeds, while that of the Grecians was marked for its solidity, graceful proportions, and richness of decorations. Thus the shaft that we employ to-day comes to us from the old Grecians, and Rome contributed the arch, which the Arabs pointed and foliated. All our ideas of architecture, good, bad, and indifferent, are derived from Greece, and although forms of beauty were there introduced, for their own sake, for ornamental purposes, the arrangement of these was not permitted to expand beyond a narrow limit, an evidence of which will be found in the conventional treatment of the anthemion (the Greek honeysuckle) and other similar objects, known as Grecian ornaments. These were, in turn, made available by the Romans, who freely used all Grecian details, adding to, enriching, and expanding the whole, until they produced a style of gorgeous magnificence. The Athenians passed a law that none who

were not of a liberal birth should practise the arts; this was done to secure the elevated tone which still marks all the monuments of Greece; but the Romans availed themselves of the aid of all who were ingenious and inventive, and whatever tended to develop a taste for art received their approbation. Of invention, comparatively, they knew little, nor was this quality for the growth of ornamental art absolutely necessary with them, seeing that Greece offered a store of details which they could use to advantage, with the exercise of a proper degree of taste and judgment. They had an eye to effect, were skilful in adapting to their own use whatever fell into their hands in their wars with other nations, and the adornment of the Capitol was one of the chief glories of the Roman. This Gibbon particularly refers to in one of his finest passages.*

The change that came over the civilized world when the

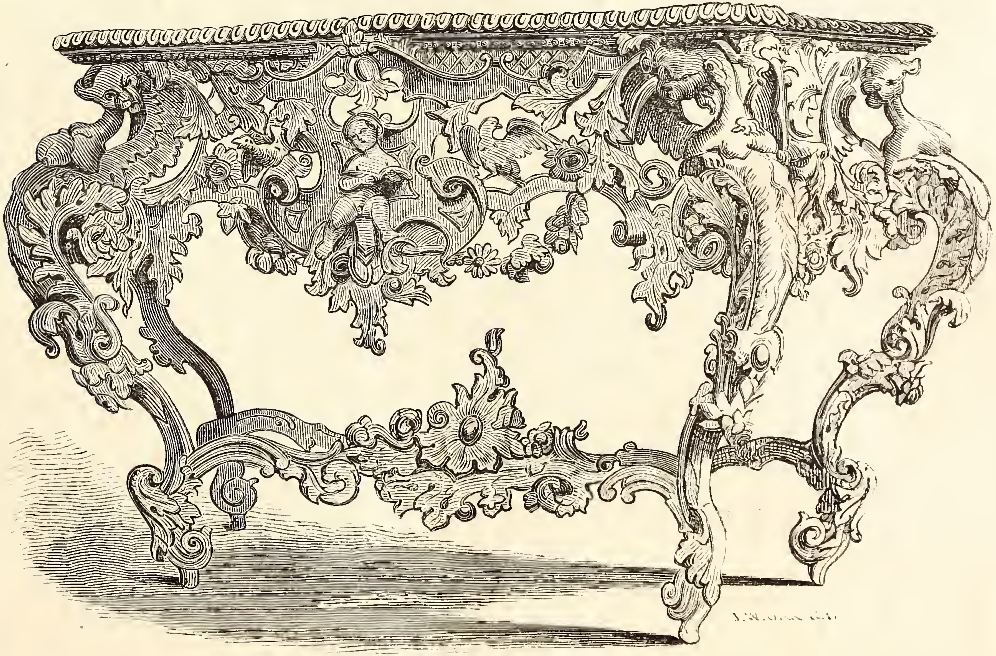
* Augustus was accustomed to boast that he had found his Capitol of brick, and that he had left it of marble. The strict economy of Vespasian was the source of his magnificence. The works of Trajan bear the stamp of his genius. The public monuments with which Hadrian adorned every province of the empire, were executed not only by his orders, but under his immediate inspection. He was himself an artist, and he loved the arts, as they conduced to the glory of the monarch. They were encouraged by the Antonines, as they contributed to the happiness of the people. But if the emperors were the first, they were not the only architects of their dominions. Their example was universally imitated by their principal subjects, who were not afraid of declaring to the world that they had spirit to conceive and wealth to accomplish the noblest undertakings. Scarcely had the proud structure of the Coliseum been dedicated at Rome, before the edifices of a smaller scale, indeed, but of the same design and materials, were erected for the use and at the expense of the cities of Capua and Verona. The inscription of the stupendous bridge of Alcantara attests that it was thrown over the Tagus by the contributions of a few Lusitanian communities. When Pliny was intrusted with the government of Bithynia and Pontus, provinces by no means the richest and most considerable of the empire, he found the cities within his jurisdiction striving with each other in every useful and ornamental work that might deserve the curiosity of strangers or the gratitude of their citizens. It was the duty of the pro-consul to supply their deficiencies, to direct their taste, and sometimes to moderate their emulation. The opulent senators of Rome and the provinces esteemed it an honor, and almost an obligation, to adorn the splendor of their age and country; and the influence of fashion very frequently supplied the want of taste or generosity.

Christian religion was first promulgated, early affected art, and the forms that were so conspicuous in temples devoted to pagan worship were, without regard to the purity of style, thrust aside; new symbols were adopted, and in place of ornaments valued chiefly for their exquisite forms, there was a resort to color; and this rather as a necessity, to express a love for decorations that the reformation could not wholly obliterate. This was the Byzantine style, which was a school of transition from ancient art, that sought the beautiful merely for the form itself, to Christian art, which used the form to express an idea. And the Byzantine was eventually merged in the Saracenic and Gothic styles. The Byzantine artists indicated the importance of the persons they painted by the size of the figure. The saints increase in size as they increase in holiness, and Christ is taller than all by a head and shoulders. All Byzantine ornaments are strictly conventional, and its leading architectural features are the trefoil and quatrefoil—the one referring to the Trinity and the other to the four Evangelists—the cross and the dome. The Saracenic is made up of an infinite play of light and shade, produced by geometric lines, and an endless variety of forms from the vegetable kingdom—the Mohammedan religion prohibiting the introduction of figures into any work of art—a loss that is compensated for in a great measure by the beauty of their delicate arabesques. Where the design is fully carried out the effect is remarkable, and it is now frequently resorted to for ornamental purposes. The Venetians saw the beauty of the leading lines and details of the Arabian houses, and many of these they adopted; and while we frequently admire the objects of ornamental art placed within our reach, we are not always aware that the embellishment we value so highly is derived from the same source. The Gothic style is essentially pointed and geometric, presenting an infinite repetition of conventional forms, united with exact imitation of natural objects. It is displayed chiefly in ecclesiastical edifices, and its most striking characteristics are, its spires and pinnacles, pointed arches, vaulted roofs, clustered pillars, large buttresses, profusion of ornament, and a predominance of the perpendicular over the horizontal. It flourished chiefly in the north of Europe, but in

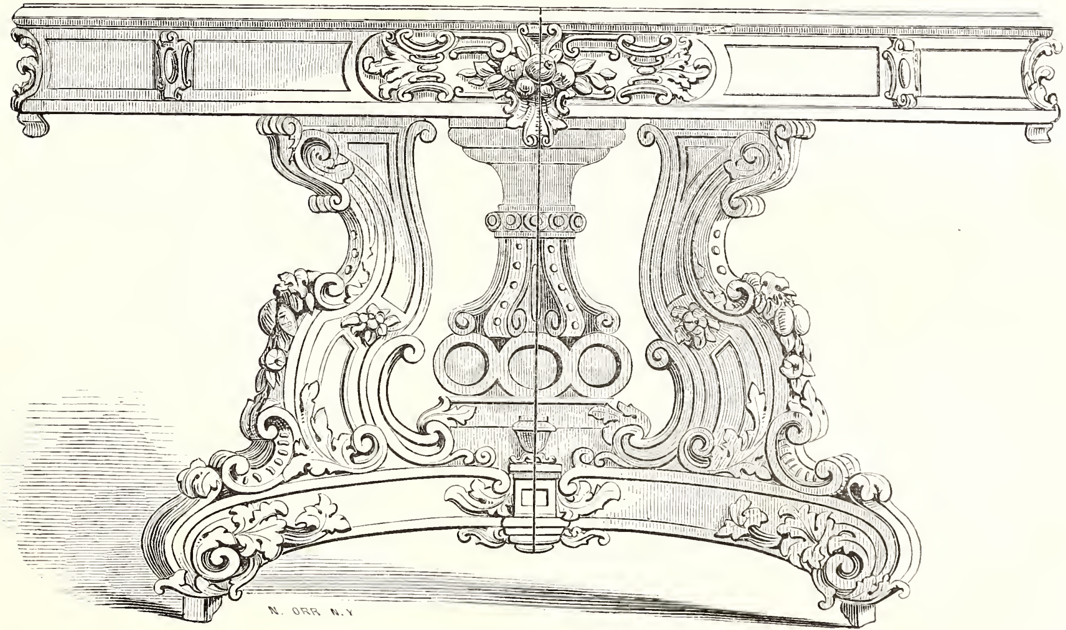
the sixteenth century it fell into disuse, and after a long rest it has been revived with great spirit and energy.

The three last named styles, the Byzantine, Saracenic, and Gothic, sprang from the three original styles already alluded to, and again there was a change effected at the commencement of the thirteenth century, known as "La Renaissance," or revival of art, and a return to Grecian and Roman ideas of beauty, as expressed in works that have been preserved to us of the best periods of art in those countries. The reformation went through several gradations—the Trecento in the fourteenth century, the Quattrocento in the fifteenth century, the Cinquecento in the early half of the sixteenth century, and subsequently the Louis Quatorze, the Louis Quinze, and the Rococo—the last being the degenerate period of a revival that found its highest development in the Cinquecento.

The extravagance of the rococo cannot be better illustrated than by referring to an engraving of an elaborately carved console table, of Genoese work, here introduced, the excessive ornamentation of which is the more apparent when brought in contact with the harmony and good taste displayed in the extension table opposite, which, we are happy to say, is of American workmanship. The ornaments of the latter are appropriate and well conceived; the parts are harmonious, and while the general impression is one of pleasure, we feel also that it may be put to a daily use with comfort and convenience to all. The console table, on the contrary, was evidently designed with reference to a gaudiness of effect, and an elaboration of ornaments, heaped one upon another to an excess positively painful. All ideas of utility are lost sight of; the designer seems to have set no value on unadorned surfaces, and the construction is every where covered up and interfered with, with the exception of the portion of the legs which necessarily bears the greatest amount of strain, and that is worked down to the smallest possible dimensions, confirming on closer inspection the first impression, that in point of utility it is wholly worthless, and for a purely ornamental purpose it is equally objectionable, seeing that it sets at defiance all our views of what really constitutes the beautiful in this as in other matters of taste.



CONSOLE TABLE.



EXTENSI(N TABLE.

TABLE TOP—CARVED WOOD.

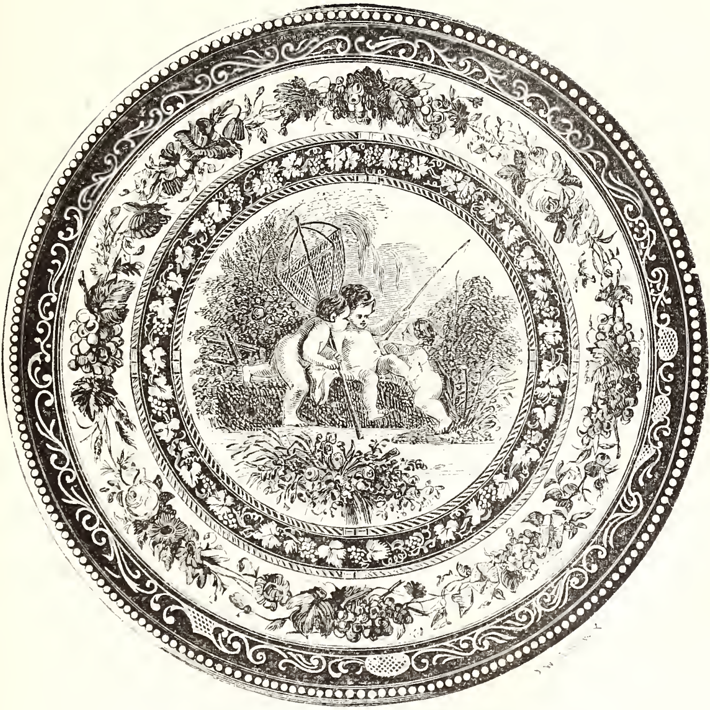


TABLE TOP—(PAINTED PORCELAIN). p. 307.

The Renaissance was the grafting of all that was beautiful, genial, and intellectual in the antique development on the complete and well-organized system of Christian art. It dates from about the Venetian conquest in 1204. Its highest development, as already stated, was in the sixteenth century. That of the fourteenth century consisted, for the most part, of conventional scroll work and foliage. The introduction of exact natural imitations was the characteristic of the fifteenth century; but these details were treated strictly in accordance with the laws of symmetry in their arrangement. At this period was also introduced that peculiar and arbitrary form of pierced and scrolled shields, or cartouches, as illustrated in the Iliad Salver, page 186, which eventually became the most characteristic details of the Renaissance, except during the short period of the prevalence of the Cinquecento, when they were generally discarded, as was every element not found in ancient examples. Greater license was used in the Louis Quatorze style; color was less frequently resorted to, and the stucco of that period was employed to the exclusion of almost every thing else, till it was finally debased in the Louis Quinze and the Rococo, in which, as we have already shown, there is a florid and extravagant development of the previous mannerism, sometimes characterized by a picturesque irregularity of details, always scorning rules, and making use of natural, conventional, and monstrous forms at will.

One of the first principles of decorative art is, that in all manufactures, ornament must hold a place subordinate to that of utility; and when, by its exuberance, ornament interferes with utility, it is misplaced and vulgar. This has already been shown in the console table, but the importance of the subject will warrant us in turning to it again, and we here present two table tops, which exemplify it to a remarkable degree. The first is of Swiss workmanship, and the material is a very light colored wood, carved with great delicacy and much spirit. The second is of French porcelain, and forms the top of a small ornamental table, mounted in bronze richly gilt, and given on page 189.

Now a table, of all things, should have utility to recommend

it to our notice, and when it ceases to be available for the ordinary purposes to which such a piece of furniture is put, it is rendered worthless in our sight, or no better than a toy. Here, then, is a table, carved in wood, with figures in high relief on its surface. It matters not how well the carver has done his part; the grapes, the leaves, and the flowers may be admirably treated, but the utility of the table is destroyed, for no one could place securely on it a pitcher or a dish; and even if it could be made available, daily use would destroy the finer and more prominent points of the design, and the irregularities of the surface would soon be disfigured with dust, which could not readily be removed. In a word, the artist has wasted his time and misapplied his talents. The carving of the standard is well enough, for that is the appropriate place for this style of ornament, but it must be manifest that the top of the table should remain unadorned if the artist has nothing but his cutting tools to resort to, when he would improve its appearance.

In the porcelain table top these difficulties are obviated. In that we have a perfectly smooth and flat surface—just such a surface as a table top should present—and yet it is rich in elaborate decorations. The vines and flowers, far more beautifully wrought, are there; no dust can disfigure its face, no heat warp it, and no ordinary acid that might possibly be spilt upon its surface will disfigure it; all ordinary wear it will stand, and for generations it may be preserved without deteriorating in value. But still it is open to criticism, and the point to which we call attention is too little regarded; it is that of placing figures in a position where they are liable at all times to be viewed upside down, the effect of which will be quite apparent by reversing the engraving for a moment. If figures are placed on a flat surface which is intended to remain horizontal, the difficulty we speak of is unavoidable, unless it is approached only on one side. The effect of this we see in plates, dishes, salvers, etc. It is, however, unnecessary to resort to this mode of decorating such articles, for the same space could be filled with some fitting design that would appear equally well from all points. One can readily call to mind a variety of ornaments of this kind at the disposal of the designer, particularly

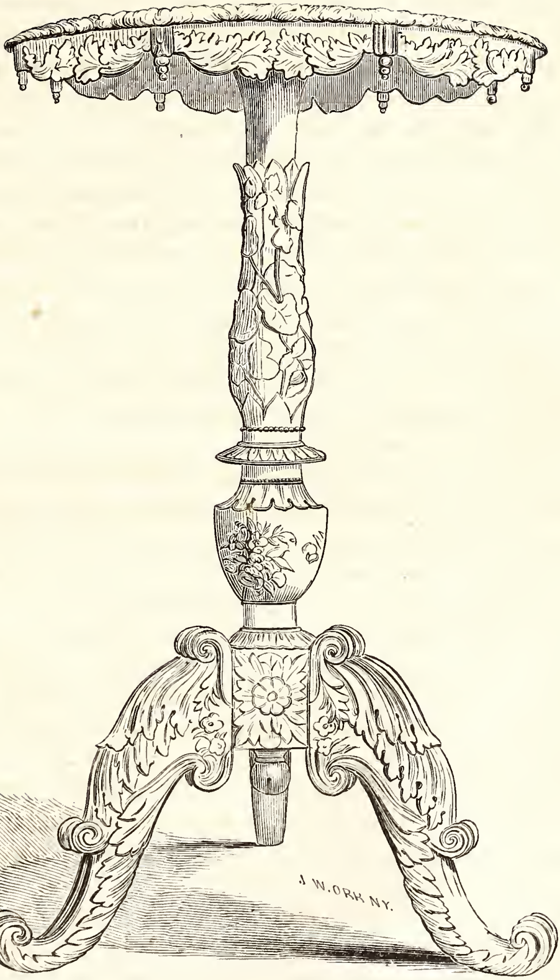


TABLE STAND—CARVED WOOD.

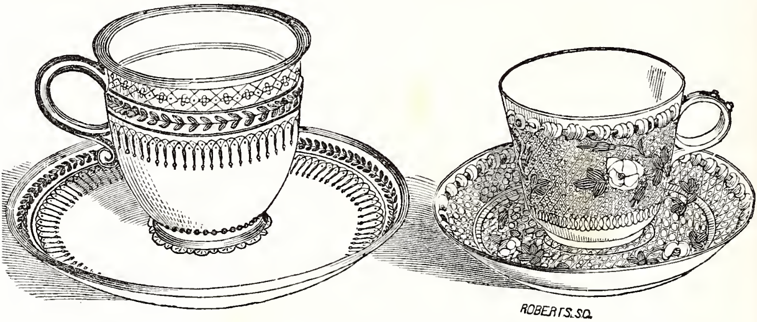
arabesque patterns, which would answer the purpose well, and save the annoyance of either having to turn the article or rest satisfied with seeing the figures standing on their heads. Nor is this objection confined to the articles named, for many of our carpets and rug patterns require us to step over bridges, birds, trees, and even mountains, all of which are introduced with about as much taste as is displayed in the feeble attempts of the Chinese to embellish whatever comes from their hands.

And here we offer other examples of a want of due consideration of the end that should be had in view in designing articles of daily use, choosing for the purpose a number of tea-cups. These are often rich and costly, and frequently they are overloaded with ornament and gilding, heavily moulded, and clumsy in shape. The first that we offer are from the Royal Prussian Porcelain Manufactory, and they have some of these peculiarities. The one on the left is prettily ornamented with sprigs imitating red coral, the effect of which is very agreeable; but the form of the cup is such as would defy one to get at the contents without inverting it. A love of variety alone could have tempted the designer thus to sacrifice utility to novelty. Purity of form should have first commanded his consideration, and however skilful the execution, his work, lacking this quality of fitness of form to the end, can meet with no commendation.

And these remarks apply equally well to the cup on the right, the decorations of which are too heavy and massive, conveying the impression that an unnecessary quantity of material was employed in its construction, which is made to assume a metallic appearance through an excess of gilding. The whole is badly conceived, and the introduction of the form of a serpent for a handle is not in good taste. All ornament, if inappropriate, is out of place, and we cannot imagine how, or under what circumstances, a snake could be found clinging to the sides and peering into a porcelain tea-cup. The introduction, then, of this much-used ornament in this place, must be set down to the love of novelty already referred to.

The two cups here introduced are in better taste; the decorations are delicate and becoming, and we have the impression, par-

ticularly in the one on the right, that the material is in reality what it seems. The rim on the top of the one on the left is very objectionable, however, resembling in this particular a flower vase; and as a cup, it would certainly be awkward to drink from, but the arrangement of the ornaments is superior, seeing there is a more equal distribution of the adorned and unadorned surfaces.



The importance of maintaining a just balance between the surfaces that are to receive ornaments and those which should remain plain, can hardly be over-estimated; and although the necessity of such a measure may not always be apparent, the want of it will certainly be felt, even if that feeling, through a lack of culture, is not fully defined. In the tea service here presented, from the Prussian manufactory, it is illustrated. Apart from its quadrangular form, which is not agreeable, it conveys an imperfect idea of the designer's meaning; the impression is a confused one, and the eye instinctively wanders over the elaborately adorned surface for a spot on which the eye may pause and rest; but, finding nothing but a gaudy painted vignette in every panel, and a blaze of gilding above and below, it will turn to the set here presented with a feeling of relief.

This last is from the Sèvres Porcelain Manufactory. Here there is harmony in all the parts; the lights and shades are balanced; the serpent handle on the preceding page gives place to one in imitation of a bent reed, and gaudy paintings are exchanged for the honeycomb, which reveals in part the delicate pink shade of the inner surface. The cups may be used without having to

TEA SERVICE—BERLIN PORCELAIN.

p. 310.

invert them to secure their contents, and the tray is charmingly embellished with little sprigs scattered over its surface, just as they might have been dropped there by some hand. There is nothing of monotony in the design; the adornment of the cups is

unlike that of the cream-pot, which has a pattern distinct from the sugar-bowl and teapot, and the panels of these, too, are dissimilar, while throughout the whole there is a connection that would be injured if any one part were missing. This is the result of the system employed at the Sèvres manufactory, where the utmost care is taken to perfect every design. Preliminary studies for the composition are first made; the lights, shades, etc., are all decided upon; then a drawing follows in tempera for an arrangement of colors, and subsequently an elaborately finished oil painting of the whole, as it will appear when completed. Is it at all surprising that those who labor only for the moment, or to give expression to some crude idea of the beautiful, fail to produce works equally worthy of attention? Nor is it a difficult matter to illustrate this. Here are two vases (on which much time and labor have been expended) as widely separated as the poles. The one on the right is from the porcelain manufactory of Limoges, France; and if, as we have before stated, decorations must be subservient to the outline, and not impertinences challenging attention, then the exuberance here displayed must be

condemned. The foliated border, which is wholly out of proportion to the size of the vase, is carried to excess, and the figures in the vignette are thus made to appear miserably small. The mouth of the vase is inexpressive of any thing save a ragged edge, and the surface every where is covered with some device, evidently designed to hide the whole exterior. Quintilian says a work of art has a silent and uniform address, which penetrates so deeply into our inmost affections that it seems often to exceed the power of eloquence; but here we have no clear conception of the artist's meaning, for it does not appear that he had any message to deliver, and so he has cast forth the vagaries of a mind that could never have been properly trained.

Let us now examine the companion vase, and see how different will be the impression. The artist well knew that the Grecians had grace in every thing, and that taste and utility are always combined in their work; he could not, therefore, err in studying the best examples of Grecian vases, and the result we see in the form of the one before us, which, although not a servile imitation, is based on well-known models of excellence. Having accomplished this much, it is not likely that he would cover up, or hide in any way, the form that had cost him so much time to perfect; and in preparing to decorate it he remembers the rule—that all good ornament has its origin in the works of nature, and the best will be that which is suggestive of its origin—he turns to the field and gathers a few poppies, with their leaves and buds. These were enough for his purpose,* and remembering also that figures and flowers, when employed on a vase, should not be isolated, but in a continuous band, he weaves them into a wreath so as to display all their varied forms—buds, blossoms, opening flowers and leaves, all intertwined together. And then, his mind, evidently still dwelling on the models he had studied in forming his vase, he heightens the effect of his work by introducing a few Renaissance scrolls, to adorn its base and shoulders, above which there is another wreath of flowers, more delicate in form and

* Ruskin says there is beauty enough in one flower to furnish ornament for a score of cathedrals.

VASES—LIMOGES & SÈVRES PORCELAIN. p. 288.

PORCELAIN VASES. p. 313.

arranged in a more simple manner, to fit them for the place they are intended to adorn. Still there is space unoccupied, but see if there is a spot on which a leaf or scroll could be placed without injury to the whole, or if more in the way of ornament would not be dearly bought at the sacrifice of any portion of the unadorned surface.

Nor are the examples we have given rare; on the contrary, they may be found in every collection of articles making any pretension to artistic adornment; but, unfortunately, the poorer specimens predominate, and when we find one that is really elegant, a hundred are conspicuous through their uncouth shapes and vulgar display of the most florid coloring. Take, for instance, the vase on the left; was there ever any thing more ugly in this way, and would it be possible for any one to say at a glance what it is or what it was designed for? We think not, for it sets at defiance every rule of proportion, and it could be put to no earthly use other than as a sign in a crockery shop, to catch the eye of those who delight in startling effects. Compare it with the vase on the right, a genuine work of art, and see how infinitely superior the latter is to it, how beautifully it is portioned, how equally it is divided into light shade, and what an air of refinement marks even the smallest detail of its elaborate finish. Yet the modelling of the one on the left, so crude in form and so inexpressive in all its parts, probably cost quite as much labor as its refined and elegant companion; for the very effort to produce an extravagant effect involves the uneducated hand in a world of trouble. At the start the designer had no definite plan on which to work; he had never studied the rules of proportion, and valuing only that which is showy, he worked at random, distorting the form of his vase at every touch, heaping ornament on ornament without a purpose, and heightening the whole by crude and glaring colors, and an excess of gilding; believing, no doubt, that the novelty of the design would compensate for its lack of meaning. Nor does the evil end here. Uneducated in matters of taste, and surprised at what he may possibly deem his success, he multiplies the number of copies, each of which serves to check the growth of a refined feeling for the really beautiful, and thus

such works are a positive injury. They satisfy the many who are governed by the market value of the article before them, just as the tub-maker, of Tottenham Court, called on Constable to know if he had a damaged picture which he would let him have cheap, as he was fitting up a room up one pair of stairs; but they cannot create a taste for works of a higher order. And for this manufacturers are sometimes to blame. They find it easier to avoid all changes for the better in the style of their goods, where that change demands an increased amount of care, and is followed by a closer inspection of their work; this is the reason why they avail themselves of few of the opportunities to improve the work of designers, and they are equally remiss in not endeavoring to elevate them to a higher standard of excellence. Such an one would probably do all in his power to avoid any advance in matters of taste; or, rather, he would prefer to keep the public mind in abeyance to his own, by modifying every design that comes into his hands, in a manner not unlike that described in these words by Dickens:

"A great manufacturer, with whom our firm often had large dealings, dined with us last week. He knew of these schools (schools of design), and showed us a beautiful design for a carpet, which he had obtained from one of them, in which the colors were all finely harmonized. 'It will sell very well,' said he, 'after I have altered it a little to my own taste.' 'Why, what will you do with it?' I inquired. '*I must vulgarize it*,' said he, touching my elbow; 'where they have put *gray*, I shall put *scarlet;* and where you see purple here, I shall put green and yellow, or such like!' Another manufacturer, whose warehouse I was visiting only the other day, showed me a table cover, of a most chaste and handsome design, a broad, rich, gothic border, with a dark centre quite plain, which, of course, made the deep border look all the richer. 'This is very good,' said he, '*but we always like something catching in the centre.* I shall have a good bunch of peony roses and tulips, or something of that sort, for the middle.'"

The perverseness that takes pleasure in vulgarizing a pattern is easily illustrated, for examples are to be found on every hand,

JUG IN PARIAN. 74

but it is not likely that one embodying more that is really objectionable than the jug here present could be produced; and we question if many could be found who, at first sight, could say what it was intended for; we can assure the reader, however, that it is a Parian jug, of a pattern that the designer no doubt thought would attract attention, which it has not failed to do; but what impression it was intended to convey, it is impossible to say. At the first glance the body appears to have a form something akin to that of an enormous elongated egg, standing on its smallest end surrounded by flames; but here we are mistaken, for these last, on a closer examination, are evidently intended for leaves of water plants, the most luxuriant of which has been seized in a fit of desperation by a goose, (or swan, possibly,) which seems in need of some such support to keep a firmer hold than it could otherwise secure on the upper surface of the egg. The neck of the bird, thus brought into connection with the plant, is made to serve as a handle, and the wide-spreading wings have not been forgotten, for they, too, perform their part —that of a spout, by means of which the jug can be emptied of its contents. The whole thing is a monstrosity, and vulgar to a point beyond all hope of improvement on the part of one who could find any thing pleasing in such a design. It has not a redeeming quality or a feature to recommend it to our attention.

And now, to understand this more fully, let us compare the above with this exquisite ewer, also in Parian, after an antique design, and probably one of Benvenuto Cellini's. The body, it will be seen, has also the egg shape, yet how differently it has been treated; figures have been introduced, but only in a conventional manner, and this has been done with all the playfulness that could be imparted to them by an ingenious and cultivated mind. The standard, the neck and the shoulders, are all treated in a charming manner, and the work, in whatever situation it might be placed, would command our admiration and respect. The hand of the artist is seen in every line; we can feel his touch, appreciate his love of the beautiful, and regard with unalloyed pleasure the evidence of his creative skill. And herein lies the difference between these two modellers: the one worked conscientiously

and with an earnest desire to give expression to his love of the beautiful; the other, guided by no such principle, exaggerates and distorts nature, and crudely models the vagaries of an uncultivated mind, to minister to a taste as perverted as his own.

Excess is always objectionable, it matters not in what form it comes; in all the walks of life it is the same, and we loathe it as much in one thing as in another; but those who cater for us in matters of taste seldom comprehend this simple truth. They imagine that quantity will compensate for any lack of quality, and, in too many instances, that which would appear to the best advantage if treated in a simple and unpretending manner, has lavished upon it a profusion of unbecoming and meaningless ornaments. Whatever is to have a conspicuous place, whether on the sideboard or the parlor table, is seized upon with avidity, and the designer, instead of acting up to the rule, that the basic form or structural peculiarity of the article under treatment should control the ornaments with which it is to be associated in our minds, evinces an unwillingness to forego the pleasure of throwing its finest points into the shade. Under such circumstances that which is severely plain would be the most acceptable, for if it excites no pleasurable emotions, it at least offers nothing that is objectionable. Of this excess in the employment of ornament we have given several examples; it is exhibited in a peculiar manner in the console table, page 306, and the value of ornaments when subordinate to, and growing out of, the basic form of the article under treatment, is exemplified in the extension table that follows it. And here we have another instance in the form of two pitchers—the one, moulded in ordinary terra cotta, has all the extravagant profusion sometimes displayed in ivory carvings; and it is loaded down with ornaments, which are crowded together to a degree that is burdensome; the other, in Parian, maintains a simple and unpretending character, offering only in partial relief a few leaves and flowers of the calla, a plant that cannot exist without a constant supply of water, and it therefore becomes not only a suitable ornament for an article of this description, but is the more to be valued as showing a degree of thought and adaptation on the part of the designer, not displayed

PITCHER IN TERRA COTTA.

PITCHER IN PARIAN.

COFFEE POT AND PITCHER IN SILVER.

in its more showy companion, and this at once entitles it to our respect.

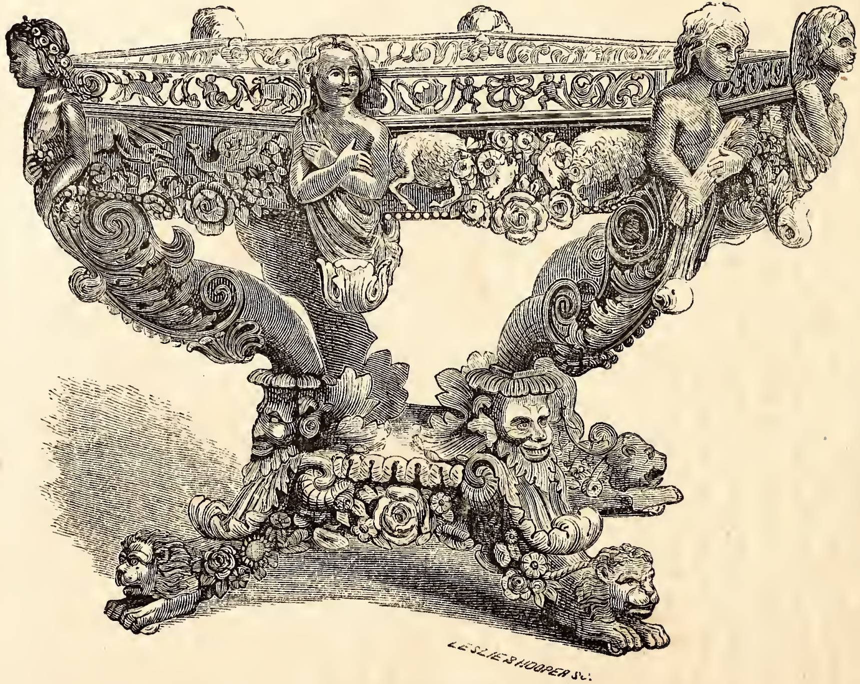
The desire to obtain new forms is never allowed to sleep, and it appears equally in the wares of the silversmith, the models that come from the workers in clay, elaborately carved furniture, and designs for textiles. This is to be deplored, and in a particular manner in works wrought in the precious metals, which, from their costliness, are likely to be preserved for a long time. But old shapes, however well proportioned and suited to the purpose for which they are intended, cannot compete with those which are striking for their novelty, even when this quality is obtained by wholly sacrificing the utility of the costly article.

The design of the Coffee Pot, in silver, here presented, is not strikingly new, yet it commends itself to our attention, not only for the grace and purity of its form, but also for the good taste displayed in its ornaments. It was evidently designed to be useful as well as elegant. The handle is graceful, and can be readily grasped; the spout, which is not inelegant in form, is so placed as to harmonize with the general outline, and at the same time serve the purpose for which it was designed. But the pitcher, also in silver, is of a different stamp. The standard is heavy, the outline of the body is forced into a variety of curves which are not pleasing, the handle is inexpressive, and is therefore a failure; and when used it would have to be almost inverted before the contents could be poured out. And here again we see utility, symmetry, and elegance sacrificed to the love of novelty manifested by many persons of uneducated taste.

Of incongruities in art we have probably given examples enough, yet we know of no fault more conspicuous in our art products, or one that more surely accompanies every effort of the designer who has not thoroughly mastered the subject to which his attention is turned. Nor is it surprising that such is the case, seeing that men whose names have been handed down to us as models of excellence in their several departments have left to posterity, with their finest productions, works rendered conspicuous by the incongruities that disfigure them—monuments, literally, of their folly and abuse of one of God's most precious gifts.

Such was the world's estimate of the picture of King Charles and his Queen, who were represented by Houthorst as Apollo and Diana, sitting in the clouds, and the Duke of Buckingham, under the figure of Mercury, introducing to them the arts and sciences—for which absurdity he received three thousand florins, a service of plate for twelve, and a horse. And with this may be classed Philip Duval's picture of the Duchess of Richmond as Venus receiving arms from Vulcan, with head-dress and bracelets of the style then in vogue at Versailles! Hondius, too, was carried away by the grand style, and commenced painting by selecting for his subject the "Burning of Troy." It proved a miserable failure, of course, and it was only after he had exhibited a picture of the "dog market" that he met with success. Carlo Marratti painted the Earl of Sunderland in a loose drapery, whole length, like an apostle. Abraham has been represented in the act of sacrificing Isaac by blowing out his brains with a blunderbuss. In a picture of the separation between the patriarch and Lot, the latter is pointing to the cities on the banks of the Jordan, which are represented by buildings with domes. Tintoret armed the Israelites with fusils; David has left to us a picture of the naked Romans and Sabins going into action with helmets on their heads, and spears and shields in their hands; and the Benedictine monks were introduced into the "Marriage of Cana," by Veronese.

But we have only referred to these incongruities in paintings of artists whose names are well known, to show how easily men of refined feelings have been led astray; and if, with all their high appreciation of their art, they did not see and feel that they had stepped beyond the bounds of propriety, it is hardly to be expected that less cultivated minds would be free from like imperfections. Nor do we look for it, but rather do we seek to show in a humble way, how careful all who minister to our comfort and taste should be to give us only such works as will have a beneficial influence. Were this so, all would in time have a higher appreciation of that which is genuine; but so long as this feeling is wanting, we must look for startling effects, and the distortion of every natural object that the designer can convert to



ROSEWOOD TABLE,

his own use. It was this that led a designer to exhibit at our Crystal Palace a clock in the form of a rose, over which a green beetle crawled, to mark the hours on the outer petals. And the same feeling animated the engraver who, carried away with a love of Nuremberg iron work, placed scroll hinges on the imaginary gates of Paradise. We daily see heavy weights supported on the frail and delicate stems of the fuchsia and lily; jets of gas burst forth from the delicate flowers of the convolvulus, pottery ware is made to imitate metal, and metal is painted to resemble stone. Lace veils are wrought with views of the Crystal Palace, and in pastry we are supplied with naval engagements.* Ornaments are introduced wherever there is an opening, without regard to their real end, and thus it is we often see them in a position quite at variance with our ideas of propriety and good taste. Here is an example, and one more to the purpose, we hope and believe, it would be difficult to find. It is a centre-table, of rosewood, with a marble top, octagon in shape, and the carving is bold enough to suit the most enthusiastic admirer of high relief. But here are caryatides with their heads rising above that which they support, and between these are caryatides actually supported by that which they should support; while the form of the legs is such that the whole weight must be sustained by the mere lateral adhesion of the fibre at their smallest diameter. Whatever has nothing to do is a positive incumbrance, and following out this rule, the greater part of the ornaments here introduced only add to the defects of a design that has nothing of elegance, strength, or utility to recommend it to our attention. Had it any of these qualities it would not require such an oppressive weight of meaningless scrolls and figures to secure a favorable notice; and any resort to this method of hiding defects is as unbecoming as it would be for a lady to wear a brooch that fastened no portion of her dress, or a chain of gold without a watch or some other article of value attached to it.

* It was said in 1814 that the pastry cooks who furnished Guerriers, Constitutions, and Javas for public dinners, realized more profit from their work of taste than either the painters and engravers who executed the same subjects on canvas or copper.

Every thing that is strained, forced, or unnatural, is repulsive. An excess of color, an elaboration of carved ornaments, or extravagance of any kind in matters of taste, should meet a well-merited censure. This is the only way to correct an evil, which, if permitted to go unchecked, will lead to the debasement of art. It does not require long study or close application to see the more prominent faults in our present style of decoration. A mere glance will show that these little figures, called "The Vintage," although represented as walking, could not move a step with the tub of grape juice, as they now hold it. The whole thing is false, and therefore unpardonable; and knowing this, it becomes the lovers of art to see that every work of like pretensions, whether it be rough in form or elegantly wrought, in nowise violates the well-known laws of nature.

CHAPTER XX.

ORNAMENT.

TASTE—which has been described as the finest ornament and purest luxury of a land—is a thing of culture, and to its full enjoyment we may not hope to attain till the eye has been trained as well as the mind.

A hundred years ago the opinion was expressed in England, that the arts could only reach the highest degree of perfection in despotic countries; and, whatever might have been the cause, it was proclaimed, that whereas in Rome the arts advanced as liberty declined, in Great Britain, on the other hand, where the principles of liberty predominate, the arts have ever been at a low ebb—a course of reasoning somewhat on a par with that of the French savans, who could only account for the great number of eminent lawyers at Paris and Toulouse, by attributing it to some peculiarity of the climate; until some one, pointing to the Universities in those places, asked if it could be that they exerted a beneficial influence over society.* And so we might turn to the history of Rome and find that the spread of the arts was directly traceable to the schools established by the several masters, and the interest manifested for the public good by private individuals.

The very opposite of this prevailed in England at the time to which attention has been called; for the Monthly Review of 1756 remarked on the extraordinary fact, that in a country in which

* D'Israeli relates this anecdote.

so many natural advantages depended on the flourishing state of its manufactures, the study, the peculiar object of which is elegance of form, should have been so little encouraged by ministers, men of fortune, and merchants.

So long ago as the time of Charles I., a school was established in England, under the patronage of the Crown, for art culture; though, unhappily, it met with no success. There was no lack of interest in the subject on the part of the King, for the first display of real taste in England was during his reign, and with the royal family the arts were in a measure banished from the country. He sent to Italy for Vandyck and Albano, but Inigo Jones was at hand to encourage his taste for architecture; and at the suggestion of Rubens he purchased the cartoons of Raphael, which had remained unused in Flanders, from the time they were sent there by Leo X. to be copied in tapestry, the money for this work having never been paid.

Gerbier, of Antwerp, subsequently endeavored to found a similar school in London; but, instead of resulting in good, his absurdities brought it into contempt. Queen Anne showed that she was not unmindful of the advantages to be derived from a correct taste, and, to set an example, studied drawing under Gibson, the dwarf, who also instructed her sister, the Princess of Orange. And Mary de Medici likewise designed well, and submitted her drawing to Rubens, for correction. Modelling in the academy, wrote Barry in one of his letters to Burke, is not likely to mislead one, and must be useful to men of real genius. Lord Arundel, says Evelyn, thought that one who could not design a little would not make an honest man. Sir Joshua Reynolds, all his life long, felt his deficiencies in drawing, and bitterly regretted not having had the advantages derived from a proper course of training; and of West it is related, that whilst residing for a limited time with one of his father's friends, he derived great advantage from the conversation of the governess of the house, a young English lady well acquainted with art and the Latin and Greek poets, who loved to point out to the young artist the most picturesque passages.*

* Dunlap.

But it is not necessary here to enumerate even the names of the many who have aided the spread of a love of art; nothing of the kind is required of us, for all admit its refining influence, and therefore our first endeavor should be to encourage its growth by drawing attention to the finest examples of creative skill. In art, as in every thing else, just as the twig is bent the tree inclines, and the student who early devotes himself to a study of Morland's pigs, will not be likely to enjoy and appreciate to the full Raphael's transcendent productions. The tub-maker who would be satisfied with a damaged picture, providing he could give it a market value by attaching to it Constable's name, could never comprehend art's true mission; as did a poor curate in one of the mud villages on the coast of England, on the walls of whose dark, low, underground parlor, there was discovered, by one who had occasion to visit him, a print of Stothard's Canterbury Pilgrims, which the poor man little less than worshipped.

A cultivated mind is certainly the one best fitted to enjoy the beauties of nature, and the importance of that culture, as considered in our day, is practically answered in the number and efficiency of our public schools. But public schools, while they answer one great end, do not go far enough; for, as it has already been remarked, the eye must be cultivated as well as the mind. Copley says, "there is a luxury in seeing as well as in eating and drinking; the more we indulge the less we are to be restrained; and," he adds, "indulgence in art I think innocent and laudable." And Galen held that the whole head was made for the eyes alone.

In the way of education, we tax all our resources to have that which is best and most likely to result advantageously. We have schools of every grade, from the primary to the university. Skilful teachers are daily employed to fill the minds of the pupils with the beauties of history, the profound mysteries of the more abstruse sciences, and in the charms of poetry in our own language, and that of other lands. The rich and the poor, the bright and the dull, the native and the alien, are alike urged to come to the storehouse and partake of the treasures—the wealth of learning which is freely distributed to all who hunger and thirst after

knowledge. Yet one thing is lacking. The boy may recite whole pages of Virgil; can he tell in what the plough of to-day differs from that in the Georgics? Has he been taught the importance of practical observations, and can he at the word express himself equally well with the pencil and the pen? If not, then he has yet to learn in his intercourse with the world that which he should have acquired with his letters; but, whatever proficiency he may then make, in after life he will never so fully master the rules of proportion, and the harmony of color, or learn how to discriminate when called upon for an opinion in matters of taste. Here, then, we see that much has yet to be done to perfect our system of education, the current of which has been confined almost exclusively to one channel. But to this subject we shall turn again. Children of natural abilities, we know, are easily trained, and in nothing quicker than a love of the beautiful. They are early attracted by color, which, in all probability, is the first thing that commands their attention without a thought; for a knowledge of form requires study, and in the contrast of form we find the superior excellence of the finest specimens of ornamental art.* This is variety for the sake of beauty; but variety for the sake of variety, so conspicuous in many of our art-products, destroys a rule of order and is subservient to a taste that delights in startling effects.

The wares of the Hindoo are gorgeous combinations of the most exquisite forms and colors; but they never offend good taste. His designs have not the diversified character of a higher culture, but they are eminently adapted to the fabrics of his loom, which, when first brought to Rome, sold for a hundred times their original cost. The Chinese, with greater resources, is far his inferior, and when he attempts the beautiful he displays his skill in carving ivory balls, and other childish curiosities. He can build a gigantic wall, as a means of protection against the Nomades, and construct a canal that exhibits sound practical skill; but in all matters of taste he is very deficient, and his tent-shaped house is not one whit in advance of the days of Confucius. The Turk's love of the beautiful marks every thing that comes from

* Dugald Stuart.

his hand. The style of ornamenting peculiar to the Arab (which has always been valued for its elegance and richness) was imported into Europe through Venice, and in the sixteenth century it was employed to the almost exclusion of other forms. In the works of the German goldsmiths and French binders of that period it is very conspicuous. The Peruvians naturally united the useful with the beautiful. Their forms were all borrowed from the animal and vegetable kingdoms, and a peculiar custom —that of never allowing articles of clay to come to the table twice—gave rise to large manufactories of pottery, in which a certain degree of elegance was attained. The Aztecs gave a fantastic form to their ornamental art, which, like that of ancient Egypt, was governed by certain laws of their religion. The likenesses of their kings were preserved in sculpture, and the world has yet to decipher the rude, but picturesque monuments, which still keep watch over the site of their former greatness. Neither the Peruvians nor Aztecs knew the use of iron, and with tools greatly inferior to our own, they carved their figures in basalt and granite. They also worked in gold and silver, and the specimens still preserved show how well they understood the art.

But of modern nations, France has taken the lead in all that relates to ornamental art. The elegant and the useful have there been combined to a degree that has not been attained by any other nation. All her goods bear the unmistakable stamp of culture, and the superior finish and style peculiar to them have nearly driven competitors out of markets where the beautiful is at all appreciated—forcing producers into the conviction that there is an end to be attained besides that of utility, and that if they would compete, they, too, must encourage ornamental art, and raise up their own designers.

England, no laggard when her interest is concerned, was made to feel her inferiority in this respect when her wares were placed beside those of her rival in the Great Exhibition of 1851. In the beginning of the reign of George III., that country was paying annually to France and other nations a sum nearly equivalent to £200,000 for engraving alone. Boydell, through his own exertions, and a judicious encouragement of this branch

of art on the part of the sovereign, completely turned the tables, and a greater sum was annually paid into England for like works. But the advantage thus gained in one particular was lost through an indifference to the importance of sustaining other departments. Articles of utility still continued to be manufactured there of the best materials, but with slight reference to the beautiful in form, and prior to 1815 there was no collection at all available to which those engaged in trades requiring a knowledge of ornamental art could refer, whilst France, ever looking to the interest of her artisans, had long had her national collection, and for centuries no pains have there been spared to develop the national taste. Of a love of art there never has been a lack in England since its revival, and West, who had ample opportunities of judging, says: "I know of no people, since the Greeks, so likely to attain to excellence in the arts as the people of England, if the same spirit and love for them were diffused and cherished among them, as it was among the subjects of Grecian States." Art in England, in West's day, and nearly up to the present time, was completely isolated. It was considered a subject of study for the few, and not a source of gratification and improvement for the many; whereas in Greece every thing was intimately associated with the arts. They were discussed at all times in public, and the men who had done most to elevate them were in turn elevated in the estimation of the people, who, we find, in all things associated the arts with their pursuits and recreations.

It is not long since the time when the wares of Birmingham and Staffordshire were moulded altogether after stereotyped forms, and in England there was not even an ambitious desire on the part of the manufacturers to repeat in clay the beautiful forms that Flaxman modelled for Wedgwood, or in metals and textiles the exquisite designs that might easily have been borrowed from the East; but gaudiness of effect, and goods cheaper than could be produced elsewhere, seemed to be the guiding principle of manufacturers who had millions at their command and tens of thousands in their employ. If they borrowed at all, it was only a blind imitation. Thus, at one time every article of furniture was after the Chinese, that being the style in vogue. Subse-

quently the Gothic claimed a like share of attention, and more recently the Greek and Roman forms alone could please a changeable taste or satisfy a demand for novelty. In each of these orders there is something of real worth, but instead of taking them in turn, to the exclusion of all others, it would have been more in keeping with good taste to have ascertained the exact adaptation of each, choosing only such as happily blended an expression of beauty with fitness or utility.

We have already alluded to the influence of the great exposition on the English mind, and we must again refer to it. One of the objections to that exposition was the certainty that the country would be deluged with foreign articles and new tastes created, which could not be catered for at home. And after it was opened to the public, the press declared that a sense of mortification in matters of art appeared to have seized upon the minds of all who took an interest in the subject. To the manufacturers it was self-evident, that while they lacked not machinery or industry to carry forward any great work, there was a lack of inventive genius in the land to give their products an attractive form. They knew there was a growing tendency to an increased refinement, and that the demand for ornamental art (almost unknown when they first supplied the market with goods) had become pressing; and they were also aware that France, ever alive to her best interests, for the last quarter of a century had annually employed the most cultivated designers to lecture alternately at Paris and Lyons on the subject of decorative arts. But these things had not aroused them to greater activity. They were confident that the quality of their goods was unsurpassed; that the machinery with which they wrought such excellent fabrics was perfect of its kind; and looking upon beauty of form as little better than a trick to set off an inferior article, they rigidly set their backs against all innovations of the kind. And it was only when all eyes turned from that which was valued for its utility to that which combined the same quality with beauty of expression, that they took the alarm, and then no efforts were spared to regain lost ground.

One of the first results was an increased activity on the part

of the Board of Trade. The government advanced liberal sums to encourage investigation, and those who were most likely to know the extent of an evil so apparent, and the best means of preventing a recurrence of the like humiliation, were called to the stand. One declared that the goods yearly imported from France could be manufactured at home, were the designs placed in the hands of the English workmen; at the same time he expressed the conviction that the French article would not sell without regard to its particular merit. Another house thus gave its testimony: "I have been acquainted with the manufactures of this country for more than twenty years. I have generally found that we have been much superior to foreign countries in the general manufacture, but greatly inferior in the art of design. The great mass of the people in this country, not merely the lower and middle classes, have not their tastes cultivated in proportion to their education." A third, on being asked to what cause he attributed the superiority of the manufacture of gloves in France, gave the significant reply, "To the knowledge the workman has of the shape of the hand." And in a speech in Manchester, Mr. Cobden said: "Take the French as calico printers—we derive all that we know of calico printing from them; we have scarcely a color that is not of French invention; scarcely any combination to produce a new effect but we have borrowed from the French. We do not know what we shall have to print, or what the ladies will wear, till we find out what the French are preparing for the next spring."

Then came the conviction that the deficiency could not be remedied by pointing out the evil, and that what had been left undone must now be undertaken by those who were impressed with its importance. It was not too late to adopt some general principle, by which expression could be given to the several parts of their products; or, employ a language that would address itself as well to the imagination as to the eye; and from that date it became the one great object to improve the form of every article of utility.

The first step was to establish schools of design, in the metropolis and manufacturing districts. These sprang up through-

out England, in Scotland, and even in Ireland. Teachers were employed, and the old and the young were alike induced to avail themselves of the opportunity thus afforded them of improving their tastes. To the young, especially, this was an exceedingly fortunate circumstance; and even those advanced in life found the schools attractive.

But how were they to derive the greatest amount of good from the liberality of the enlightened and cultivated? Vertue relates a tradition of Sir Christopher Wren, that he went once a year to survey the roof of the Chapel of King's College, and said that if a man would show him where to place the first stone, he would engage to build such another. The manufacturers of the nineteenth century were equally at a loss where to begin. They had learned to their cost that nothing is beautiful that is not true, and that truth can only be attained by an intimate acquaintance with the laws of nature and the properties of bodies. Here a wide field was open for investigation, and the words of West—"schools of art are designed to give taste to every species of manufactures, to polish rudeness into elegance and soften massiveness into grace"—assumed an importance never before accorded to them. A new value was imparted to the flowers of the field and the minerals of the earth. Nature's manner of working was contrasted with that of her children, and the result was just as humiliating to the inquirer as it was a century before to Hogarth, whose beautiful expression of our present ideas of ornamental art has experienced the same neglect that the artist met with in his own day.*

During the past five years Schools of Design in England have

* In describing a clock made by order of government, for keeping correct time at sea, which had not the beauty of form that would have harmonized with its mechanism, Hogarth thus gives utterance to his feelings: "Had a machine for this purpose been nature's work, the whole and every individual part might have had exquisite beauty of form, without danger of destroying the nicety of its motion, even as if ornament had been the sole aim; its movements, too, might have been graceful, without one superfluous tittle being added for either of those lively purposes. Now this is that curious difference between the fitness of nature's machines, and those made by mortal hands."

grown into importance, in spite of all the obstacles, in the way of prejudice, want of experienced teachers, and the depressive gloom at one time cast over the country by an unpopular and expensive war; and in the larger towns every facility is offered those who are disposed to improve them. Younger students go through a prescribed course, beginning with linear, geometry, and mechanical drawing, and ending with drawing the human figure from the life. And those who are actually employed in the production of goods for the market, are encouraged to study, as far as in them lies, the principles on which the designs before them are based. Time alone can complete the work. The present generation of artisans must pass away, and the youths now under tuition take their places, before the country can hope to reap the whole advantage to be derived from a scientific course of instruction. The English, however, are not impatient, and they can afford to wait till the seeds planted with so much care have matured their fruit.

But deeply as we are interested in the progress of the art manufactures of England, we are in duty bound to give more attention to our own lack of artistic skill. If England is far behind France in design, we are equally far behind England, and it might almost be said that we are wholly deficient in creative art, with the exception of such as finds expression in works valued exclusively for their utility.

Let us first see what is thought of our artistic skill by others, and then, by looking into the subject, we may judge whether it is as it appears at the first sight.

The London Art Journal holds to the maxim that a man does not like to be told of his deficiencies, and yet it speaks of us in this unqualified manner: "The Anglo-American seems the only nation in whom a love of ornament is not inherent. The Yankee whittles a stick, but his cuttings never take a decorative form; his activity vents itself in destroying, not in ornamenting; he is a utilitarian, not a decorator; he can invent an elegant sewing machine, but not a Jacquard loom; an electric telegraph, but not an embroidering machine"—a picture certainly not very flattering, but one that we do not feel wholly at liberty to reject.

Blackwood said of the Paris Exposition, "The Americans are as poor and practical as at our own exhibition. Colt's revolvers, now as then, are the chief centre of interest; and, to economize the labor of the assistant exhibitor, specimens of these deadly tools are hung in chains, like cups by a public well, to be snapped and clicked by every comer who wishes to try them, until, at last, they are rendered totally useless."

Madame de Merlin, in her notes on America, is so extravagant as to say that all that is beautiful is here forbidden; and she intimates that our minds are absorbed by the movements of a high-pressure steam engine, and our hearts are changed into bank-notes; while another ascribes the neglect of the arts in America, to an ardor for speculation and the all-absorbing pursuit of dollars, sacrificing to the positive and materially useful, those pursuits and refinements which are the grace and embellishment of human existence.

Our European caterers seem perfectly aware that as a people we cannot discriminate in the nicer shades of ornamental art. This is one reason why so few of their finer products were sent to the New York Crystal Palace; and when surprise was expressed at the inferiority of some of the wares exhibited in Paris by Wedgwood, it was declared that the greater part were designed for exportation, to suit the "fancies" of foreign markets. The United States import the wares of this well-known house; the articles referred to were in part evidently intended for our use, and no doubt the manufacturer finds it a very convenient thing to ship off the work of indifferent hands—just as we exchange our showy calicoes for gold dust and ivory on the coast of Africa.

Now, why is this? We are not deficient in the powers of observation, though we may never have applied them to this end. As a class, our workmen are greatly superior to those of Europe. They have advantages of education unknown in any other country, and by all odds, they are the most intelligent mechanics in the world. And to this class, more than to any other, we look for the preservation of the Union. They are its bulwark and its strength, and if they are but indifferent designers, it is because this faculty has not been called into play. Here it is an honor,

not a loss of position, for a man to work daily at some useful calling; and the highest inducements are held out to him to make himself a useful, industrious, and valued member of society. Why may he not take up ornamental art, and furnish us with the designs we need? The field is a wide one, and the reward is sure. In nearly every case the arts have been traced to an humble origin. The germ in the youthful Giotto was discovered in the forms he had sketched, on a flat stone, of the sheep he was tending. From the works of the fifteenth century, in niello, we trace the rise of line engraving. The lines then produced with lampblack and oil, resembled rude pen-and-ink drawings; the same lines to-day, drawn by more skilful hands, are the perfection of the art.

The Hindoo, on the banks of the Ganges, used a block to stamp his tissues before the foundation of Rome, and the caravans of the Edomites bore the precious web across the desert of Persia, and laid it at the feet of Babylonian kings. Ages after Rome and Greece had tumbled into dust, a printer of Mentz carved a font of movable types from the same block, smeared them with ink, and at small cost, gave to the world the first printed copy of the Bible—a step that at once raised man from ignorance to knowledge, from weakness to strength. And still later, at a time bordering almost on our own day, the Anglo-Saxon traced upon the same block the forms that nature taught him were her choicest works, carved them with a skill that Angelo might have envied, and opened a way to the highest development of the graver's art.

The famed purple of Tyre is traced to the Tyrian Hercules, the mouth of whose dog was found stained with the color, after crushing one of the many shell-fish found upon the coast. A search led to the discovery of the imperial treasure found in the purpura, a spiral shell-fish thrown up from the depths of the sea. Twice in the liquid thus collected he dipped the finest wool of Syria, and wove a robe that none but kings might wear. The Chaldean and Persian kings were clothed in purple, and in purple Pharaoh robed Joseph. The mourning Trojans prepared for the remains of Hector a purple pall, and of purple were the sails of

Cleopatra's barge. Dives lived in purple, and in purple the mocking Jews clothed our Saviour.

With the fall of Tyre the art of extracting the dye was lost, and the natural dyes of India and the cochineal of the New World had to supply the demand for the royal color. And when the few remaining fragments of Tyrian dye were nearly lost through the lapse of time, the art had not been re-discovered. But a poor Irishwoman, in the time of Charles II., it was ascertained, supported herself by marking linen with a crimson liquid, extracted from shell-fish found upon the coast. This led to an investigation, and the result is, the monarchs of Europe, of to-day, if so disposed, may be robed in the color that Solomon thought worthy for the veil of the Temple.

For a long time glass was supposed to be a modern discovery, but to the Phœnicians we are indebted for it. To Egypt the art was first carried, and the workers in glass in that country excelled all others. It was employed by them more than by modern nations, and in every conceivable way it was turned to account. In the ruins of Herculaneum glass has been brought to light, and recent discoveries in Nineveh show that the Assyrians employed lenses, as well as ordinary articles of daily use, made of the purest glass. With the aid of this invention the stars of the heavens have been arranged in classes, and the temperature of the ocean's depths recorded, and the last and greatest triumph of creative art was the Crystal Palace, that outshone in splendor the fabled gifts of Aladdin.

The Egyptians carved rude forms in stone and deified them as gods. The sphinx, ibis, and the nobler form of man, they wrought in materials that defy the tooth of time. For ages thus they worked without a change of form; for the religion of the country allowed of so much truth of expression, and no more. The Greeks were restrained by no such trammels, and in their hands the art reached its utmost perfection—for what nation can hope to excel the beautiful creations of Phidias and Praxiteles?

The Romans robbed the Greeks of their treasures, and hoped to master their arts; but the one was as ignoble as the other was fruitless; and when the Goths and Vandals swept over Italy, they

destroyed nearly all that art had created in centuries. And still later, in more western lands, the Iconoclasts of the Reformation hurled from their pedestals the cherished objects of art, and trampled them in the dust. But still the art lived, and still it breathes—not deep and full, as in the days of Pericles; not with the spirit that animated Phidias, but still it lives; lowly and humbly, it may be, but ever pointing to the light that hovers around the noblest efforts of creative skill. And thus, whether it springs into being in a land of darkness, or comes to us the fruit of time and culture,

"A thing of beauty is a joy for ever."

And how completely our own country exemplifies the remark that the arts and inventions which have most benefited mankind are traceable to an humble origin. Franklin employed a kite to draw the electric fluid to the earth, and Morse, with a simple contrivance, mastered and controlled that powerful agent. The value of Fulton's experiments cannot now be estimated, and to our shipbuilders is due the credit of improvements that have nearly revolutionized the commerce of the world. Our trades are not trammelled by the guild laws that weigh heavily upon the constructive talents of some countries. There is no combination here to keep men of ability in a subordinate place, but all have an equal opportunity and the same incentive to rise. This has led our mechanics to exert themselves, particularly to bring out new labor-saving machines, which best reward their inventors, and the readiness with which this peculiar faculty for inventing machines, to overcome difficulties in the way of manufacturing, may thus be illustrated. To compete successfully in the manufacture of shawls, the Bay State Company required a machine to spin a certain part of the work, which had always been done by hand at great cost. The task was assigned to a skilful workman, and with the one idea before him, at the end of five or six months he had a machine in successful operation which reduced the expense of spinning to one-twenty-fifth of the cost under the old method.

By applying machinery we have an advantage not possessed

by the middle ages. The coin that was made, as we have shown, by repeated blows on the metal, with a rude die and a heavy hammer, is now executed with the greatest precision by a simple contrivance. Then a few hundred impressions only could be

struck from the same die, and these at great cost of time and labor; now the gold and silver coins unceasingly flow from our mints. The delicate tracery in gold and silver, usually executed by the chaser, has rarely the merit of a correct design, and its fitness is never considered as it should be. Now, patterns, formed

of perforated paper, threads, or lace, may be placed between sheets of metal and passed through rollers, leaving a clear impress on the previously plain surface. The execution is more perfect and economical, and articles that once the wealthy alone could command, can now be enjoyed by those of more limited means. The same is the result of what is now known as natural printing; natural objects, such as leaves and flowers, giving the impression when subjected to a like process.

Again, take book-binding, the first materials of which were boards of oak or chestnut for the sides, connected with heavy ropes, and afterwards covered with leather or vellum. During the Middle Ages these boards were often covered with curious designs of great beauty; and, to judge of the time the work must have consumed, it is enough to know that all the minute details, however elaborate, were made up with separate tools, worked by the hand of the finisher; and this process had to be repeated on every cover. To-day the same device can be engraved on a plate of brass, with which, aided by machinery, the covers of the largest editions are embossed speedily and at small cost.

But it is not necessary that we should give instances of inventive skill; those of our own countrymen can be numbered by thousands, and will occur to the minds of almost every one; though we doubt if many can be pointed to whose labors have not been employed to one end—utility without regard to beauty of form. We never seem to consider there is no dividing line between the useful and ornamental arts; or that "utility will be still more divinely served through an alliance with beauty." It is the character and fitness of a design that should first command our attention. We are not behind the French or English in bringing out an ornamental design, once the design is placed in our hands. In this respect our activity knows no bounds, but in getting up the most desirable patterns of this description we are sadly deficient. The old Venetian invented a new shape for every glass he made, and never moulded a handle or a lip without a new fancy to it,* and although his works may not all have the same attractive qualities, they are all, at least, expressive of fitness, and

* Ruskin's Stones of Venice.

their language is just as intelligible to-day, as it was when Murano decorated with mirrors the most gorgeous palaces of Europe. The Chinese have not been surpassed, so far as the composition and glazing of porcelain are concerned, but in design and style of finish they are immeasurably behind Europeans.

But we hear some one say: "We acknowledge our want of skill in this respect; how shall we improve our tastes?" By encouraging all that leads to ornamental art. By establishing and sustaining schools of design, and by seeing that every child acquires the rudiments of drawing at the same time that he masters his geography and arithmetic. Give him access to the best models, ancient and modern; and let him receive at the hands of competent teachers such instruction as will ever after enable him to express his ideas by means of chalk and crayons. Such a department should exist in every community, and drawing should be as essential a part of every school teacher's qualifications as excellence in reading and writing. Not that we expect every teacher to be a good draughtsman, any more than we expect perfection in other branches; but as some considerable proficiency is looked for in one department, so ought we to demand it in another. Far better would it be, if a choice must necessarily be made, for a child to know something of form and how to express its just proportions, than the attainment of a little Greek and Latin; for if intended for any thing short of the professions, the dead languages will avail little; whereas a knowledge of drawing will be found useful in any position in life. But there is no need of sacrificing one of these pursuits to the other; for drawing is usually esteemed a privilege by the pupil, and may be used as an incentive to progress in other studies. The child with naturally a correct eye and a fine appreciation of the beautiful, needs but a little guidance at the start to attain to a high degree of excellence; the dull may never get beyond the rudiments, but even this small insight into the mystery of lines is of real importance.

In this country we look upon drawing as a pretty accomplishment, that a young lady may aspire to, as she does to proficiency in music. But the time spent by her over flower-painting will not be wholly lost. The lesson, though of the lightest kind, will

have some weight, for it will teach her that there is such a thing as art, and in this there is gain.

But the one who is really to be benefited by a school of design, is the artisan. To him it is of the utmost importance to know how to delineate the form of whatever he is required to construct. Properly instructed, he not only designs with greater ease, and makes himself independent of professional draughtsmen, but he is also enabled to assist those who require his mechanical skill, and know not how to express their ideas. This advantage is enjoyed to an eminent degree by the half civilized Japanese. With them many years of apprenticeship are required before one can rank as a workman; but at the expiration of that time he is perfect, so far as their arts will carry him. All are said to draw with accuracy, and without a draught they will not undertake any important work. This peculiarity has been forcibly dwelt upon by one who has recently had an opportunity of watching their movements closely. "The rapidity with which they erect and finish a building," he remarks, "is rather interesting, and they never attempt any thing of the sort till a plan of the same is drawn; the elevations, &c., are all marked out on a board, and in sight of the workmen, so that each one understands what is to be done; and precisely as is the plan, so will the building be when finished. I noticed," he continues, "if they wished to ceil a room overhead, the entire ceiling was raised at once—that is, it was fitted before any of it was put up, and raised to the place where it belonged; it is an exact fit, and only required a few nails to have the job completed. Now our style of joiner's work would be, to fit and put up each board by itself, showing that the Japanese work from measure and rule with unmistakable accuracy." And since this subject has been forced on the attention of England, the opinion has there been expressed that a ploughman would turn a truer furrow, and a hedger and ditcher make straighter and better work, for knowing how to hold a pencil and draw a line with it.

But these things can only be brought about by adopting sound principles as a basis. Art, we know, can only suggest to the mind, and composition is derived from a study of its means and

capabilities, as well as from the study of nature. In large cities there should be schools of design solely to rear up a class of teachers; but the place where, of all others, such schools would be most productive of good, are the manufacturing towns. In these the pupils would have at the same time an opportunity of studying the processes of manufacturing; and understanding these, they could adapt their designs to the wants of the public, and the nature of the materials in which they are to be wrought. Men of science should give more attention to the wants of the manufacturer, and a cordial understanding between the two would result in mutual good; for the one could throw light on many things that are yet obscure, and the other would learn the practical operations of many beautiful theories. The manufacturing arts of the ancients should be placed before the pupil, to be explained by the instructors; and committees should be appointed to visit and correspond with distant manufacturing towns and villages. This is illustrated by the course adopted in England, where, little as is there thought of our inventions, save for articles designed wholly for utility, committees have been formed and sent to this country, for the purpose of obtaining such information as could be made immediately available at home. In return, we should frequently send juries to France and England, or even to the quiet shades of Mount Athos, where the Greek students of to-day are struggling to master the arts of design under the tutelage of monks; and if they extended their search to the far off Indias, where the arts of design flourished thousands of years ago with a wild luxuriance known only to the tropics, they would find the natives, impressed with the superior tastes of civilized nations, adapting anew the natural flowers and plants of their country to the purposes of ornamental art.

And the advantages derived by society, in opening another field for the usefulness of woman, should not be lost sight of. Designing is peculiarly adapted to her tastes and habits, and wherever an opportunity has been afforded her, to increase her usefulness by a knowledge of this branch of industry, she has shown herself skilful, quick, and inventive. Some of the finest wood engravings that decorate the pages of the London Art

Journal, were executed by women, and in our leading cities there are schools of design in successful operation for their especial benefit. The attendance is not large, but the improvement is such as warrants the directors in keeping the schools open. A few dollars a quarter are usually charged for tuition, rather to give the pupil a sense of independence than to add to the funds of the school; and besides the regular pupils, a number of the teachers from the public schools receive instruction daily.

As yet there has been no proper recognition of woman's powers. Heretofore drudgery and ceaseless stitching with her needle were all that was required of her; her highest endowments have been lost sight of, and she has had no great incentive to improve her mind. Showy accomplishments will suffice, if wealthy; and if doomed to a life of drudgery in after years, the labor spent in preparing for a higher order of things is time lost. With the best education our schools have afforded, if thrown upon her own resources, she must still undergo another training before she can hope to maintain herself at all. Even then, it must be with the sacrifice of every thing but her integrity, and too often that also gives way beneath the pressure of want.

But again it will be said, "A course of training will do very well for the younger members of society; yet how are those who have come to maturity, and have but little time at their command, to improve their tastes?" And again we reply: Simply by observation. We know that whatever increases the exercise of the imagination, increases also the emotion of beauty. See, then, that there is a due regard for the beautiful in every thing to which it may be applied. "But how draw the line, and say, this shall be adorned and this shall be retained for its usefulness?" And to this we reply: A due consideration should be had for the form of every thing, from the swaddling-clothes in which the infant is first wrapped, to the sculptured stone that marks our last resting-place. Whatever speaks of the past or points to the future, and all things that relate to our comfort and well-being, should be clothed in a fitting form. There is no portion of a building, internal or external, that may not be decorated in the same way. A square window will let into our churches the light

CARVINGS IN OAK.

and air just as well as a pointed one; but the latter we associate with the overarching boughs, beneath which men first assembled to worship God; whereas the other is valued only so far as it ministers to our necessities. The rose and honeysuckle can be trained over our stiff and formal country houses, without relieving the barrenness of such fronts; but clustering in graceful lines around the porch of some humble cottage, they invite one to rest and enjoy their sweets.

And when it becomes necessary to purchase an article, and the materials are equally good, choose that which combines in the greatest degree beauty of form with utility. In selecting a paper for our walls, be guided by the size and position of the room, as well as by the style and color of the furniture—a difficult thing to bring about, it must be confessed, for there is little in our house paper that is not tawdry and in direct violation of good taste. If a room is to be newly furnished, care should be taken that in no particular it offend the eye, which is exceedingly sensitive to incongruity in color. All theories of color, it is well known, are based on the harmony of the external world. We see a violation of the laws of nature wherever our steps are turned, and the organ of sight, refusing to rest on a sky-blue fence, is the next moment forced to gaze on a carpet in which colors, mixed in a heterogeneous mass, are endeavoring to surpass each other in brilliancy and effect. Whereas, by proper attention to the harmony of color, and by giving every hue its proper media, the most pleasing sensation may be produced by a few simple shades, and the impression thus received will not soon fade from the mind.

If this subject received the attention it deserves, it would repay the student by giving him such an appreciation of real harmony as could be derived from no other source. He would find that all colors are classed; that the primaries consist of red, blue, and yellow; that the secondaries are divided into accidental, opposite, harmonious, contrasting, and complementary—all of which are composed of combinations of the primaries, as yellow and blue, in proper proportions, make a green, which is the opposite of red—and that the tertiaries are composed of combinations of

the secondaries. Each combination has its proper media, which, by the same rule, may be extended to every conceivable shade, producing in such cases the utmost harmony and beauty.

But here we are entering too wide a field. The test we have named should be applied in every case where colors are to be used, and all the influence brought to bear on such colors should be first considered before decorations are commenced. Our carpets, and, in fact, all that is intended to furnish a room, should be selected with a due regard to the end had in view. And if cold blue is balanced by a ruddy orange, warm green by a cold red, crimson by a brown, gray by a deep tawny, and a rich maroon by a poplar green or sky blue, harmony will prevail—always providing that one is selected for a key note, and that all others are subservient to it. Harmony is not lost by using intense colors, if the extremes of warm and cold are avoided, and each color is properly balanced; but the most pleasing effect is produced by selecting a low note and keeping every shade to that standard.

And as to furniture, there is no end to the application of ornamental art to such articles of utility, and certainly the intelligence of the age requires due attention to the subject. The clumsy chairs of Henry VIII. were just as serviceable as those that are now made after French patterns. The rushes that supplied Elizabeth with a carpet answered the ends of that fastidious queen as well as the imitation Brussels carpets of to-day serve our purpose. But it is hardly to be presumed that the clumsy chairs and the rushes of the House of Tudor would be admissible in our dwellings. And if we have advanced to a period that requires articles of luxury and refinement, it is certainly proper that we should furnish the designer as well as the workman to execute our orders. Great complaint is made if we go abroad for the raw materials our own country can supply—why not show the same jealousy of foreign articles of taste, and by meeting the demand with home products, drive all competitors out of the market?

There is nothing on which we bestow less thought than on a flat iron, and in this humble article we never look for any thing but utility. Yet its form admits of a graceful finish that in no way interferes with its usefulness, and in the fourteenth century

it received a full share of attention. But what is lacking in the flat iron, which never leaves the kitchen, is more than made up in the stove, designed for the parlor. In this ornamentation is carried to excess, and the effect, so far from being agreeable, is often repulsive. The idea of fitness was certainly never considered in placing a bird's nest, cooing doves, and angel forms on an article that is at times red-hot. We see this daily, and without attempting to analyze our feelings, we instinctively withdraw the eye from such an object. But if a miniature frame, surrounded by the flowers of the forget-me-not, is placed before us, the association is most agreeable. The language employed speaks to the imagination as well as to the eye. Whereas, if, instead of the forget-me-not, the folds of the serpent were entwined around it, we should be repulsed, for no one cares to see a loved form in such an embrace. Yet we are more likely to see the latter device, for the designer, seeking only for novelty of construction, seizes that which produces most effect, whether it be good or bad. Study and a regular course of training could alone lead him to avoid such an error, which, when pointed out, would appear to him as clear as the light of day.

We know well enough that certain goods sell better in our markets than others. English and American prints would stand no chance with those of France, at the same price. The quality of the cloth is no better; it must be, then, that the design makes all the difference in the world. No gloves will sell but those of French manufacture, and no cabinetmaker can draw customers to his warerooms till he spreads his tables with imported designs. It would be an insult to say that we prefer these things because they are foreign. We do not go abroad for our broadcloths and plain cottons, for in the manufacture of these goods we are not surpassed. Our carpets are as well made as the English article, and, so long as the designs are equal, they are preferred, from the simple fact that they are home products. Our printing presses and reaping machines are in demand in Europe, and in shipbuilding we stand in the front rank. These are honors, certainly; and as we have done so well in all that relates to utility, why may we not gather fresh laurels by bringing about an alliance

with beauty? To do this something more is wanted than to facilitate the progress of manufacturing. Utility may be the groundwork, but art must be the structure; for without a knowledge of art we cannot judge correctly of a design, and without a design, based upon sound principles, we cannot compete with those who have enjoyed a higher degree of culture.

A liberal employment of articles artistically adorned is one of the first steps towards awakening a taste for art. Books of elementary instruction should be placed in the hands of children; and, above all, schools of design should be opened in our manufacturing towns, to raise up a class of designers of our own. Such a work parents should take an interest in; and manufacturers, who now annually spend large sums for designs from Europe, can afford to give the cause their hearty support. They are certainly called upon, by an increased refinement, for designs of a higher order than they have been accustomed to furnish, and it is only by the alliance we have repeatedly referred to, that we may hope to diminish the superiority of our neighbors, and bring the art products of America to a level with those of France and Great Britain.